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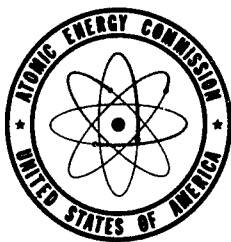
NEUTRON FLUX DISTRIBUTIONS IN THE  
MATERIALS TESTING REACTOR. PART II.  
THE  $5 \times 5$  LOADING

By  
G. O. Bright

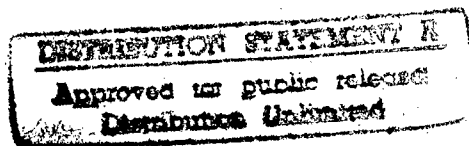
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November 17, 1953

Atomic Energy Division  
Phillips Petroleum Company  
Idaho Falls, Idaho



Technical Information Service, Oak Ridge, Tennessee



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Since nontechnical and nonessential prefatory material has been deleted, the first page of the report is page 5.

NEUTRON FLUX DISTRIBUTIONS IN THE MATERIALS TESTING REACTOR

PART II: THE 5 x 5 LOADING

by

G. O. Bright  
Technical Branch

Work performed under Contract No. AT(10-1)-205.

November 17, 1953

A B S T R A C T

Flux distribution measurements have been made in the Materials Testing Reactor with the fuel elements arranged in a symmetrical 5 x 5 loading. Three-dimensional thermal neutron flux distribution maps were made for both clean, cold fuel elements and depleted, poisoned fuel elements.

The data are presented as a series of relative activity curves and as a set of absolute flux maps. A qualitative comparison of the flux distribution is made between the 5 x 5 loading and the 3 x 9 north slab loading.

Atomic Energy Division  
PHILLIPS PETROLEUM COMPANY  
Idaho Operations Office  
Idaho Falls, Idaho

## NEUTRON FLUX DISTRIBUTIONS IN THE MATERIALS TESTING REACTOR

### PART II: THE 5 x 5 LOADING

#### I. INTRODUCTION

The Materials Testing Reactor (MTR) (1) is so designed that a great flexibility is obtained in its possible fuel element arrangement. The elements can occupy any or all of the 37 positions which are provided in the active lattice. For various reasons, primarily engineering problems dealing with water flow through the fuel and reflector, the practical limit on the number of fuel elements used is about 27. This number allows several different loadings to be made, each with its own characteristics insofar as the operation of the reactor is concerned.

The reactor was scheduled to use a 3 x 9 array as its initial loading. The flux distribution with this loading has been reported in Part I of this report (2). During the acceptance testing period, it was decided also to test the reactor using a 5 x 5 array. The reactor was operated for one complete cycle in this manner. During this time, the flux measurements described in this report were made.

#### II. DISCUSSION OF THE EXPERIMENT

A three-dimensional map of the thermal neutron flux distribution in the reactor was desired. For this purpose, the technique described in Part I of this report (2) was utilized. Briefly, the method consists of placing cobalt wires, 0.040 inches in diameter and from 26 to 42 inches long, in selected positions in the fuel elements and in the reflector. After exposure to neutrons at a low reactor power, the wires are removed and the activity along their length as a function of position in the reactor is determined. For this purpose, a special wire-scanning device has been constructed (3). Associated measurements are also made to determine the epithermal flux contribution to the cobalt activity, the absolute flux level, and a factor with which to extrapolate the flux values at low power to values which could be expected at a power of 30 megawatts.

The experiment as performed followed the procedure outlined in (2) very closely. Both the clean, cold and the depleted, poisoned runs were made for approximately one hour with the reactor at a nominal power of 60 kilowatts.

#### III. DISCUSSION OF THE DATA

The compilation of the data and its form of presentation are fully discussed in (2), pp 24 - 26. In this case, the associated measurements yielded values of epi-cadmium induced activity as shown in Fig. 1. From these values, the thermal correction factor zones were assigned as in Fig. 2.

The accuracy of the measurements is also fully discussed in (2), p 41. In brief, the error in the relative values is estimated to be within  $\pm 5\%$ ; the error in the absolute values within  $\pm 25\%$ .

The comparison between the clean and depleted conditions was made by assuming (1) that the fission rate is proportional to the thermal flux, and (2) the power (heat extracted) is proportional to the fission rate. With these assumptions, the volume integral of the thermal flux over the active lattice should be very nearly the same regardless of the position of the shim-safety rods for a constant power level.

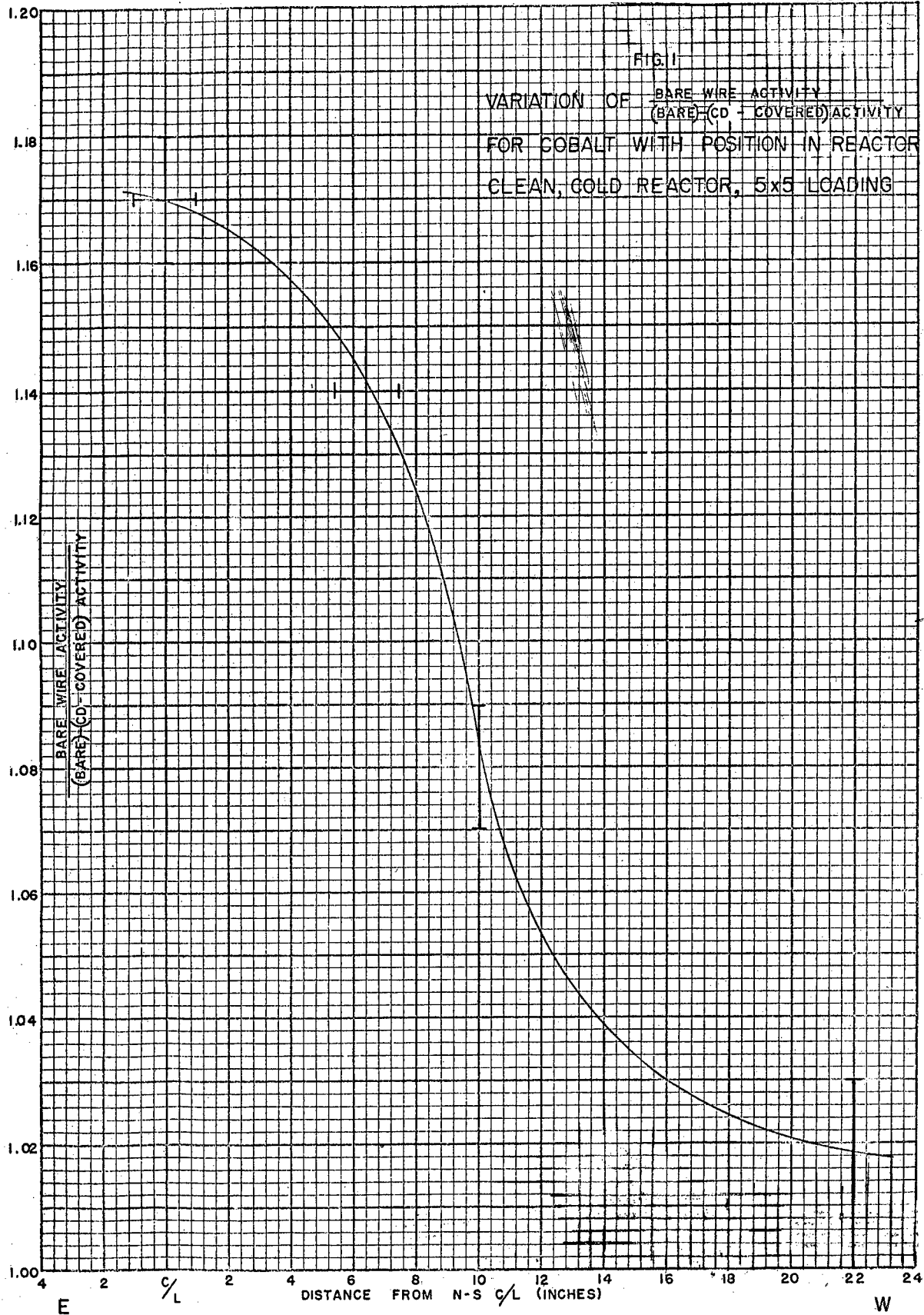
In order to obtain the volume integral of the flux over the active lattice, it was assumed that the average flux level in each fuel element is represented by the activation curve obtained from the wire in that element. Then the area under the activity curve is proportional to the volume integral over the element. The sum of the areas over the active lattice is then proportional to the total volume integral. The integrals for both reactor conditions were then made equal and normalized to a point where the absolute flux was known.

#### IV. GENERAL DISCUSSION OF THE RESULTS

Three maps were prepared from the data (Figs. 3, 4, and 5), which show, respectively, flux distribution at the clean, cold reactor centerline; at the depleted, poisoned reactor centerline; and at 6 inches below the centerline (maximum flux position) of the clean, cold reactor. The values which were obtained agree quite well with the distributions determined for the 3 x 9 array as reported in (2) in that the maximum flux for the depleted reactor is lower than for the clean reactor. The flux, in general, appears to be lower in the 5 x 5 loading than in the 3 x 9. Consideration of the maps for the two conditions, however, shows a more uniform distribution for the 5 x 5; more of a "smoothed-out" appearance. The fast flux contribution, also, appears to be somewhat higher in the 5 x 5 array than in the 3 x 9, as shown by the epi-cadmium flux values obtained from cobalt.

The centerline view of the MTR construction (Fig. 6) shows the perturbations which are present in the reflector. The lowering of the flux on the east side is evident on the maps for both the 5 x 5 and the 3 x 9 loadings. This can be explained by the presence of the large aluminum and air perturbation in the reflector on the east side. The 3 x 9 array also shows higher flux values to the south of the active lattice than to the north, whereas the 5 x 5 does not. This is probably due to the symmetry of the beam hole perturbations with respect to the active lattice in the 5 x 5 array, and the unbalance of these perturbations with respect to the active lattice in the 3 x 9 loading.

The critical position for the shim-safety rods in the 5 x 5 array was approximately 16.5 inches for the fuel rods and fully withdrawn for the beryllium rods. For the 3 x 9 array, the corresponding positions were 17 inches and fully withdrawn. A comparison of vertical traverses for the



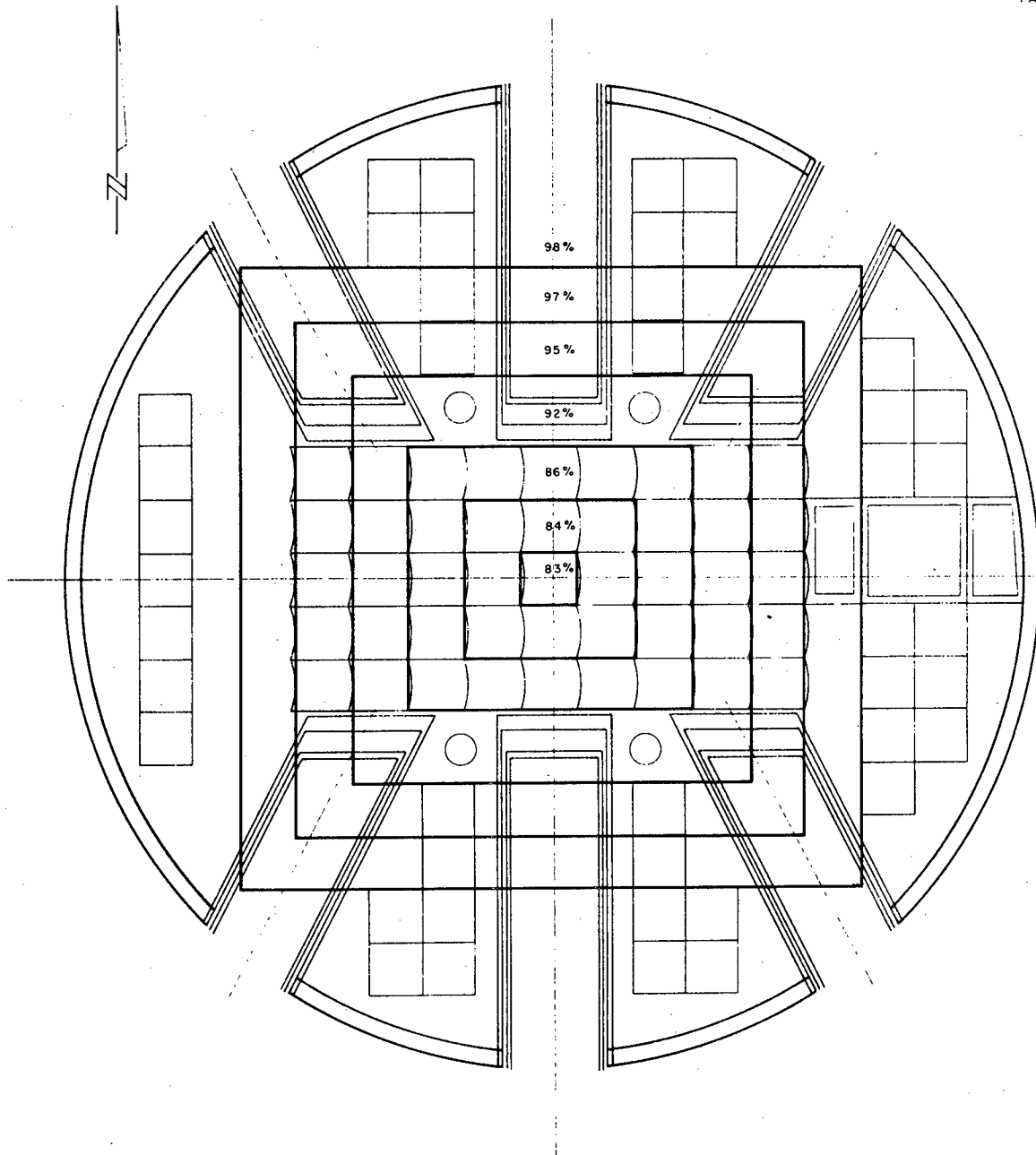


FIG. 2

ASSUMED DISTRIBUTION OF THERMAL NEUTRON  
CONTRIBUTION TO COBALT ACTIVATION IN REACTOR

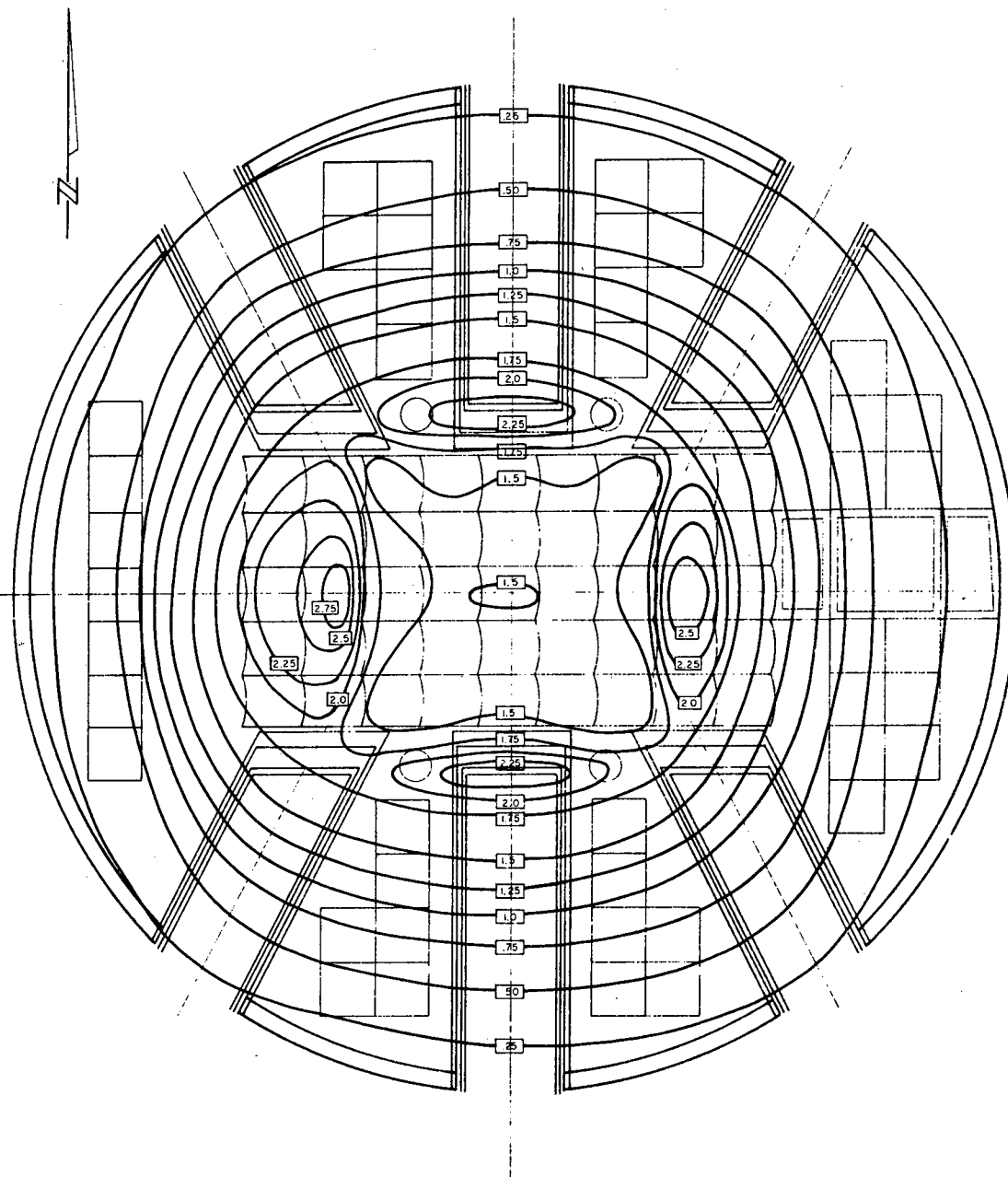


FIG. 3

ISO-FLUX THERMAL NEUTRON MAP OF MTR INTERIOR  
AT MIDPLANE OF CLEAN, COLD REACTOR. VALUES  
ARE  $\square \times 10^{14}$  NV.



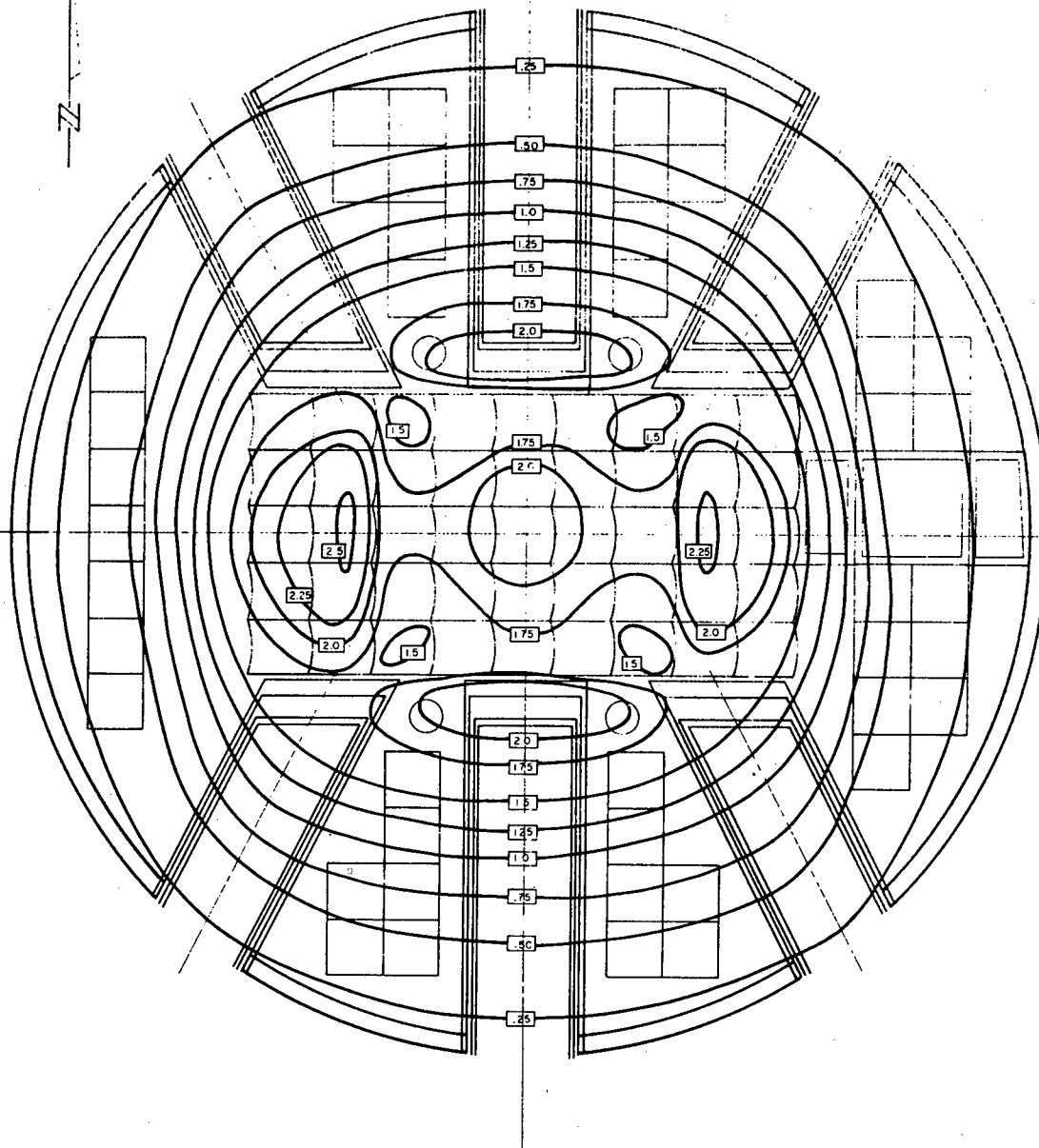


FIG. 4

ISO-FLUX THERMAL NEUTRON MAP OF MTR INTERIOR  
AT MIDPLANE OF FULLY DEPLETED REACTOR. VALUES  
ARE  $\square \times 10^{14}$  NV.

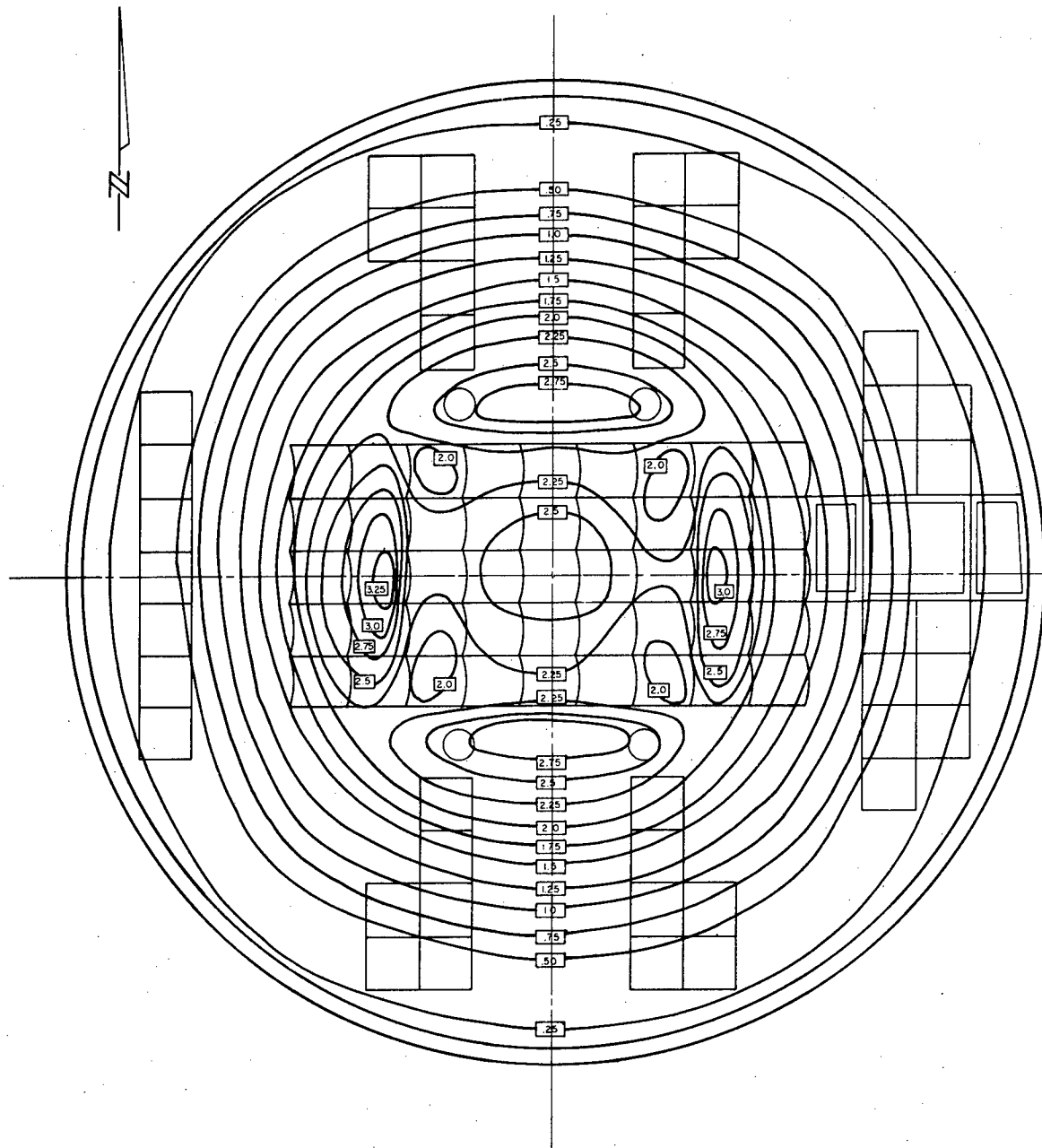


FIG. 5

ISO-FLUX THERMAL NEUTRON MAP OF MTR INTERIOR  
AT 6" INCHES BELOW MIDPLANE OF CLEAN, COLD  
REACTOR. VALUES ARE  $\square \times 10^{14}$  NV.

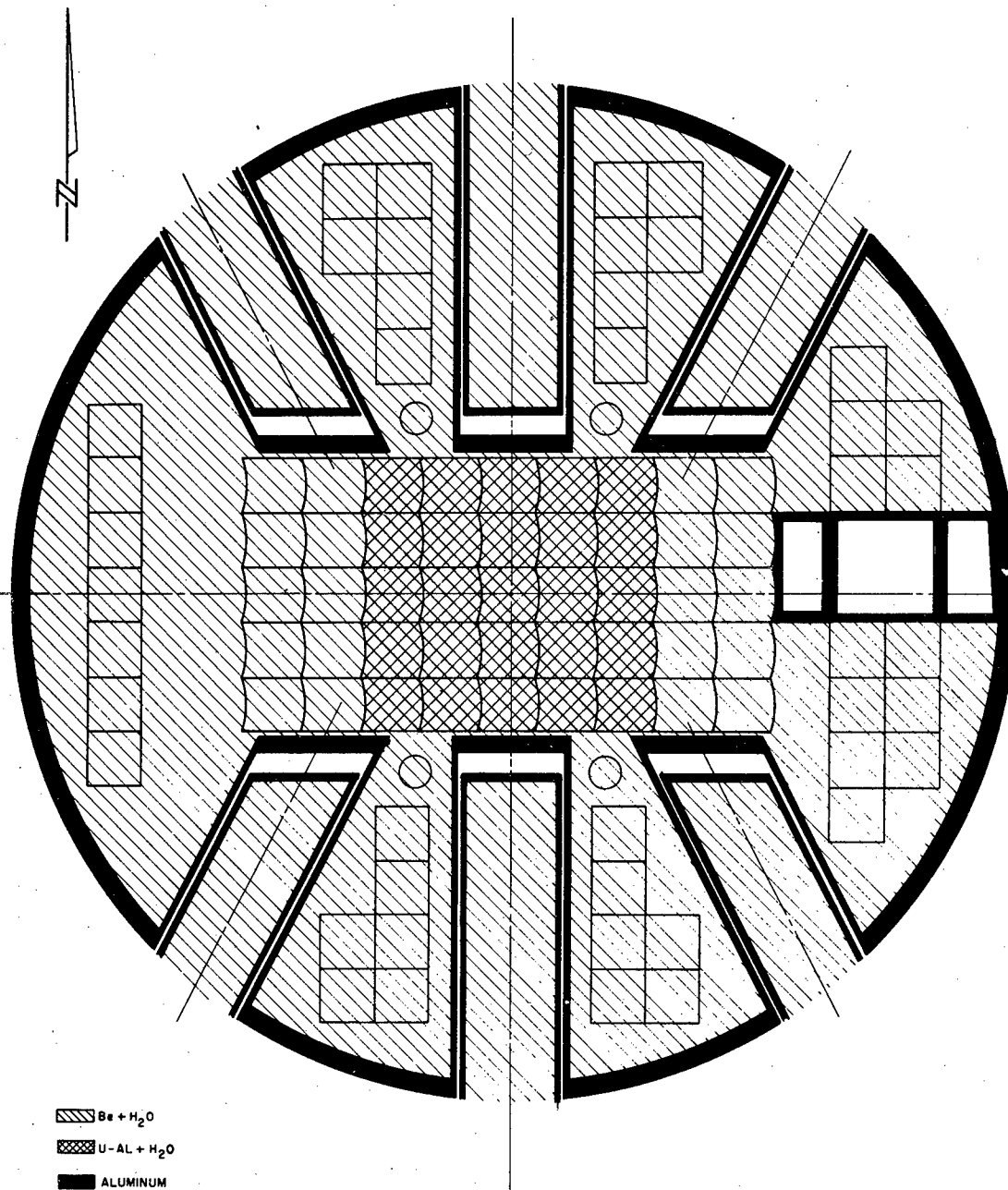


FIG. 6

MIDPLANE CROSS SECTION OF MTR SHOWING  
PERTURBATION DUE TO CONSTRUCTION.

clean, cold 3 x 9 and 5 x 5 loadings (Appendix I) shows a somewhat greater maximum flux/average flux ratio for the 5 x 5 than the 3 x 9. Some of this is due to the lower position of the fuel shim-safety rods, but most is probably due to the smaller volume of the active lattice in the 5 x 5 loading.

The various activity curves resulting from these measurements are presented in Appendix I. They are in comparative form; that is, the corresponding curves for each position are plotted on the same page.

#### V. ACKNOWLEDGMENTS

The author wishes especially to express his appreciation for the great amount of work in the taking and processing of data done by Miss F. Moran. Much credit is also due Mr. F. Schroeder, of the Instrument Development Section at the MTR, for his aid in the planning and execution of the experiment.

VI. REFERENCES

1. Materials Testing Reactor Project Handbook, C. F. Leyse and J. H. Buck, ORNL-963, May 7, 1951.
2. Neutron Flux Distributions in the Materials Testing Reactor, Part I, G. O. Bright and F. Schroeder, IDO-16047-PPCo, February 16, 1953.
3. Activated Wire Scanning Device, (Interim Report), F. Schroeder, IDO-16051-PPCo, January 27, 1953.

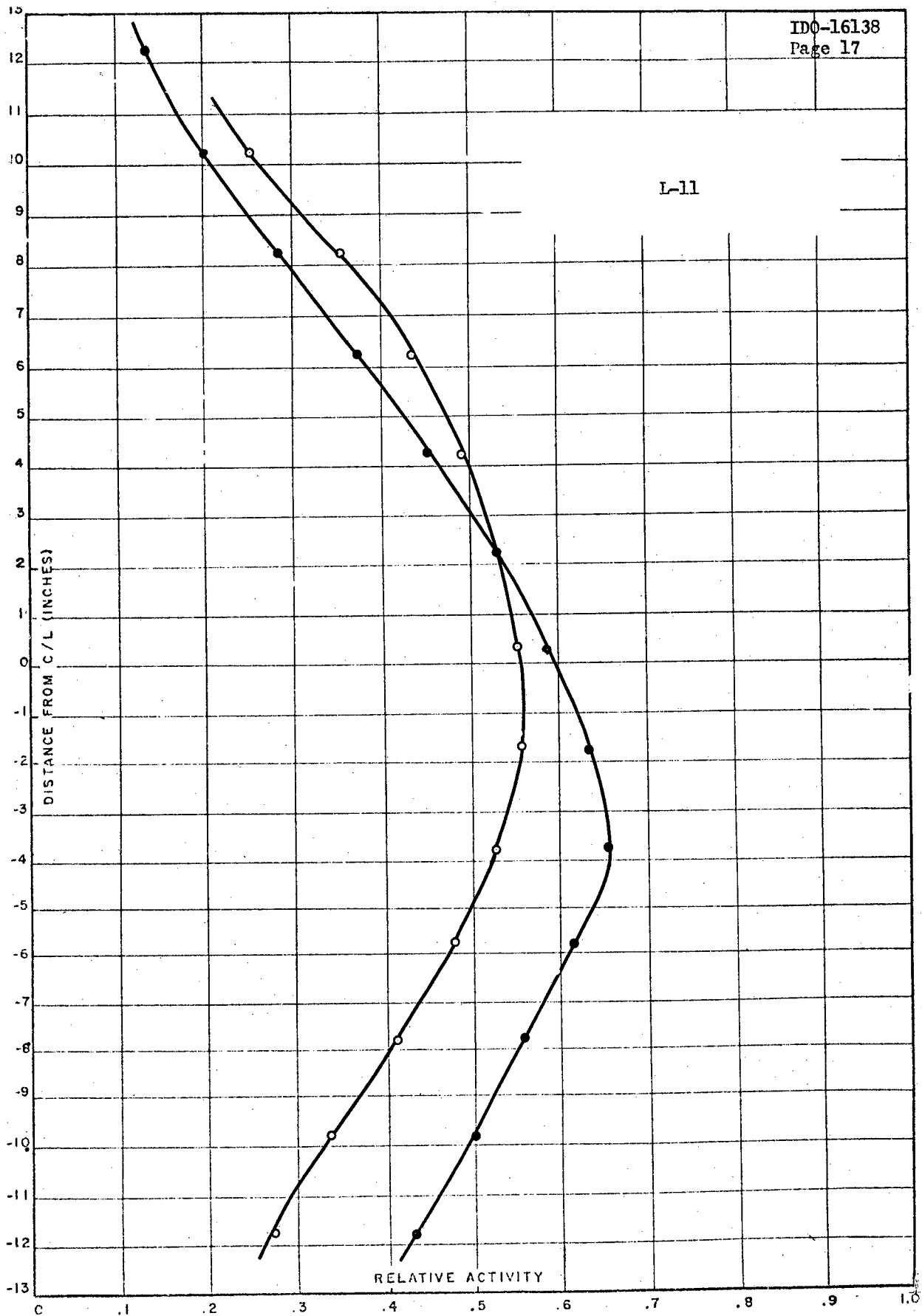
APPENDIX I

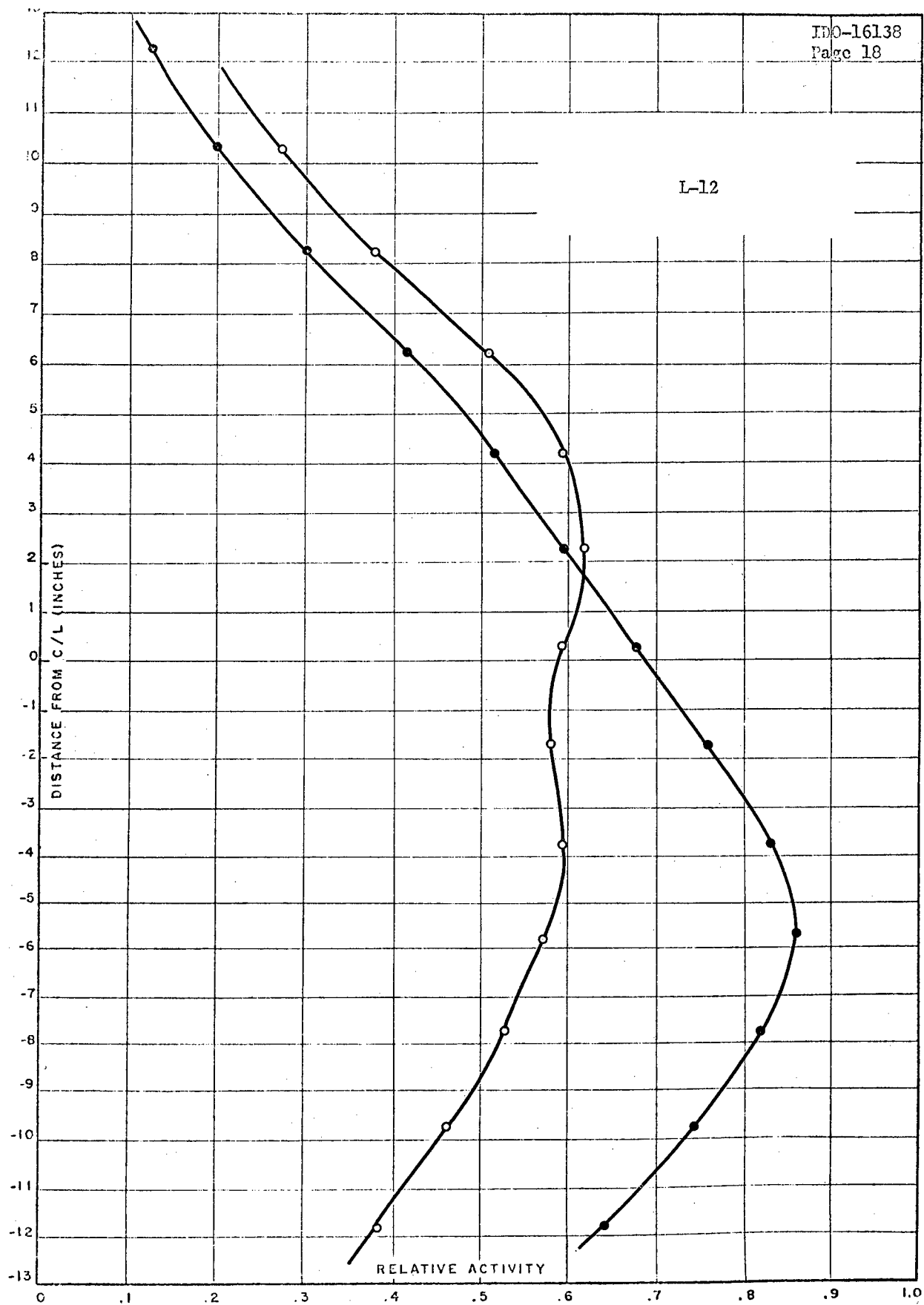
The relative activity curves for all positions which were measured are presented here. In every case, the curves are drawn such that

—●—●—●— is the clean, cold condition, and

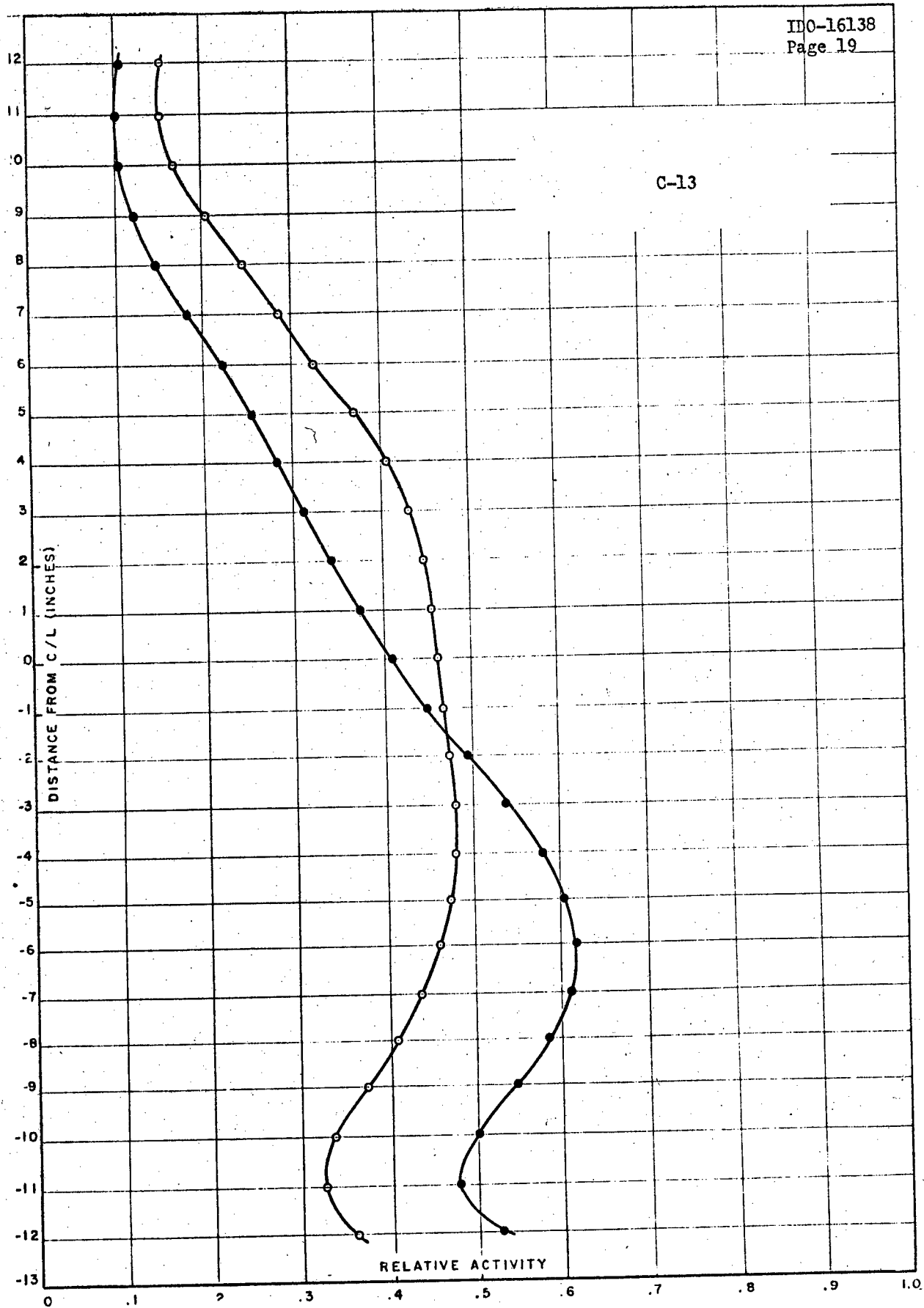
—0—0—0— is the fully-depleted condition.

These curves have been corrected for epi-cadmium-induced activity and represent only relative thermal flux. Under the conditions which prevailed at the time of measurement, the absolute value of the thermal flux may be obtained by multiplying the relative activity by  $3.14 \times 10^{14}$  n/cm<sup>2</sup>/sec.

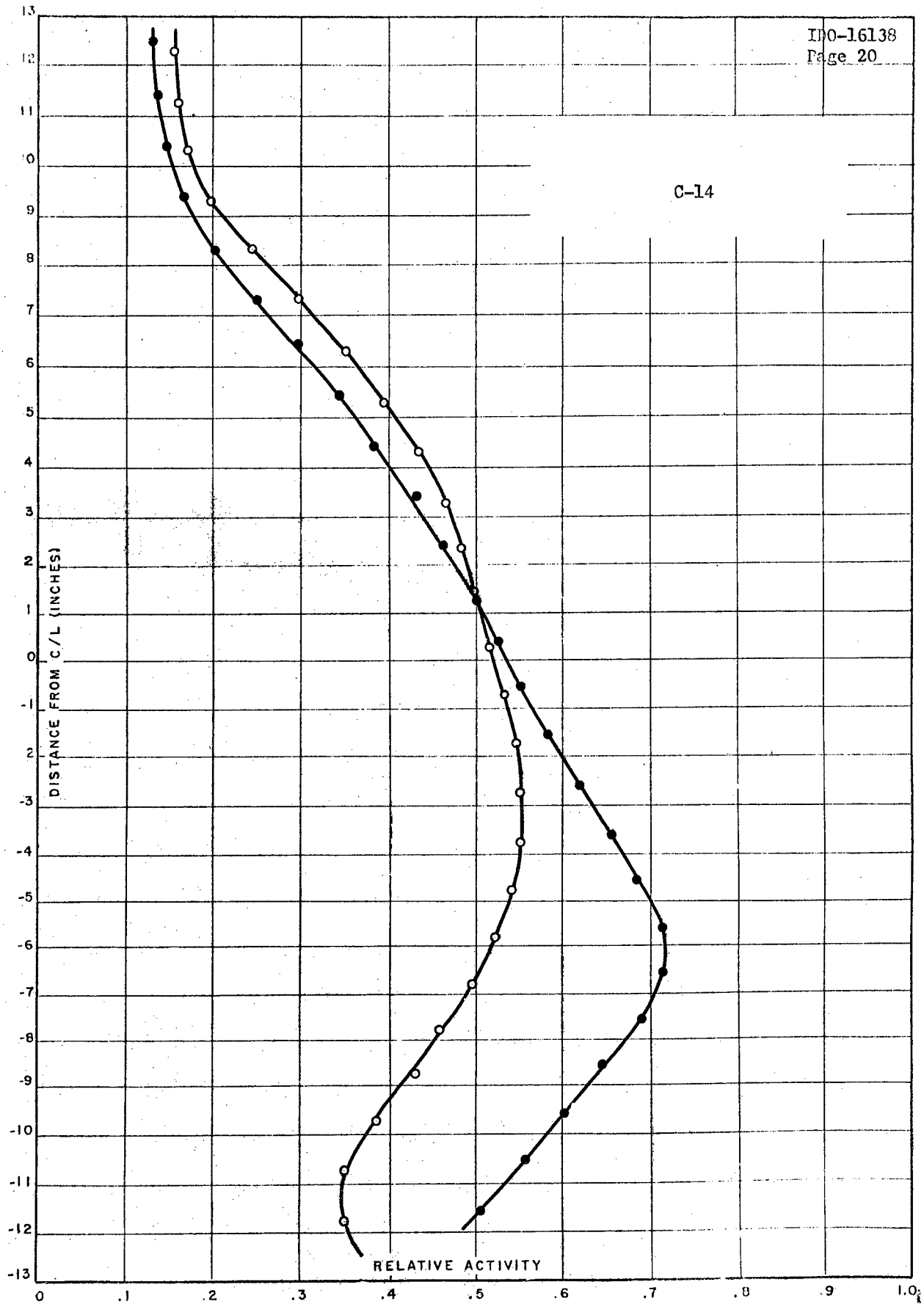


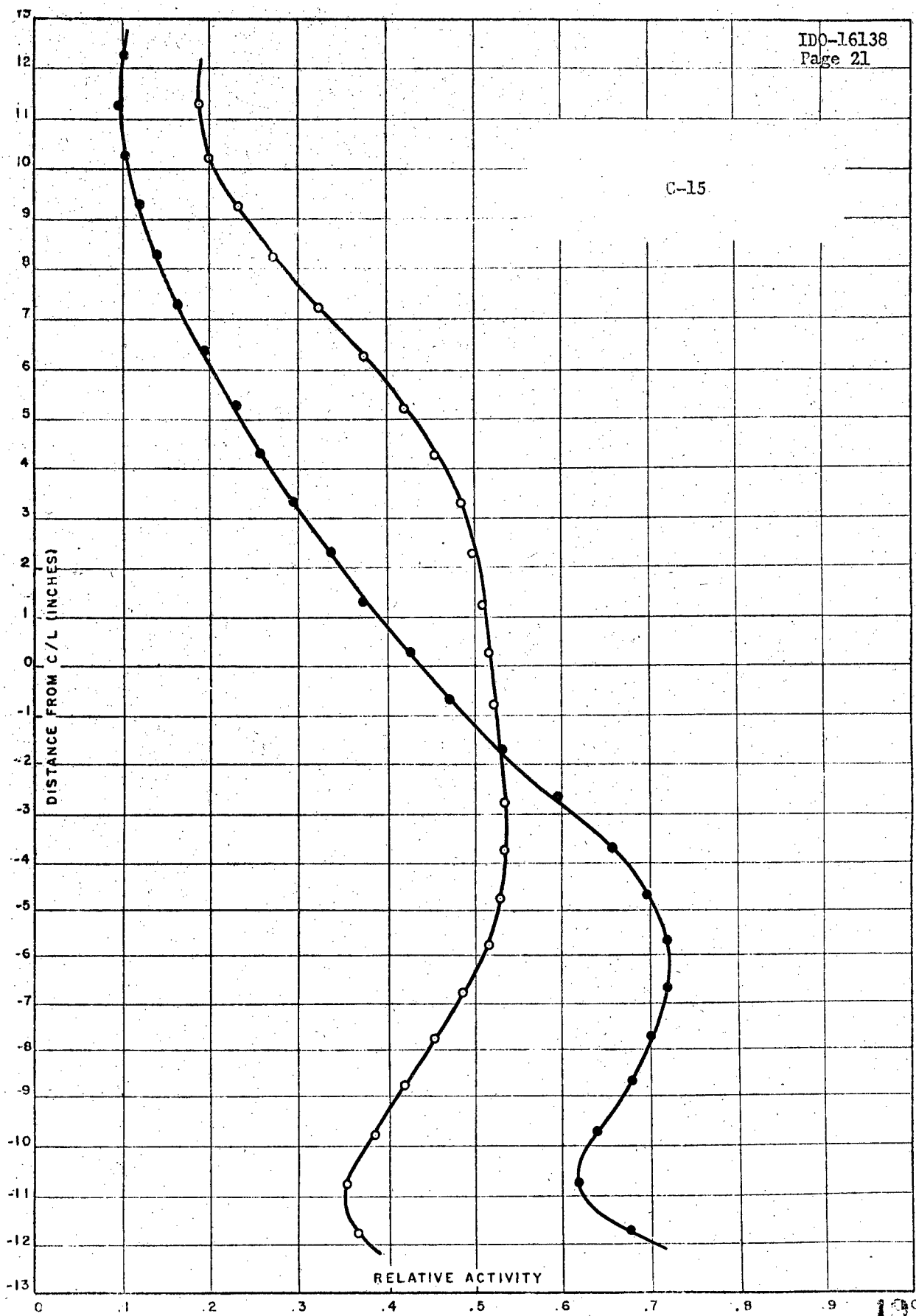




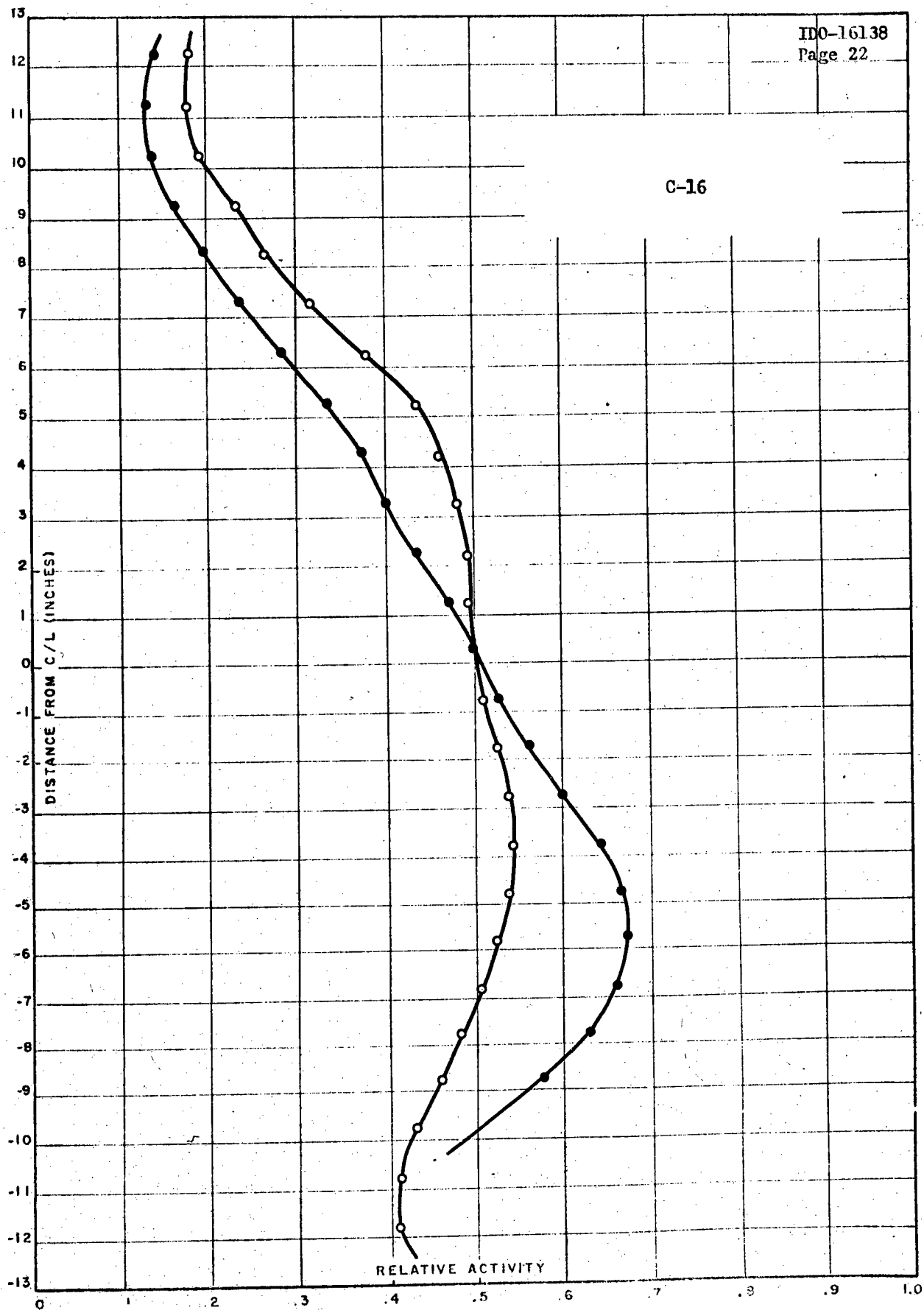


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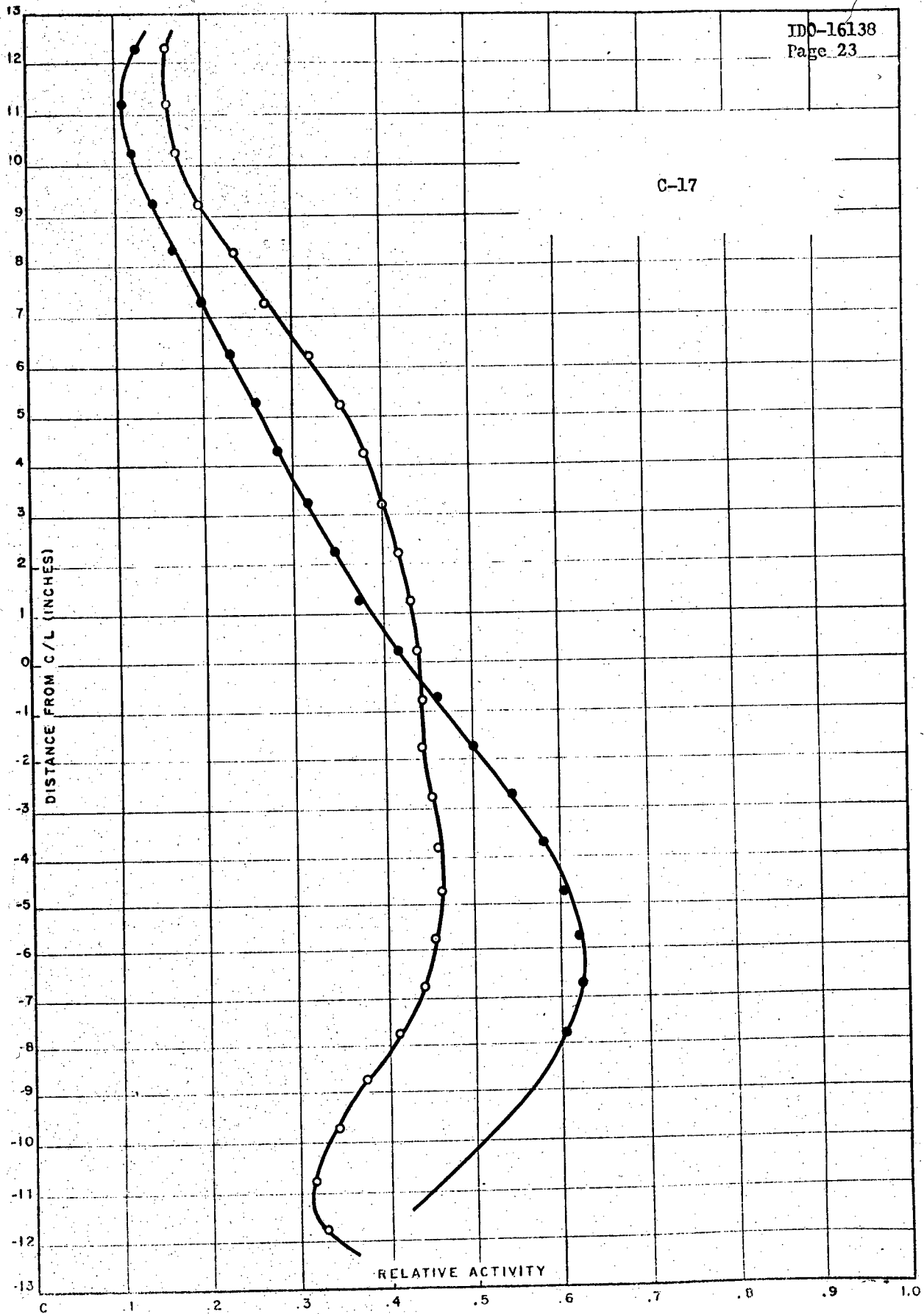


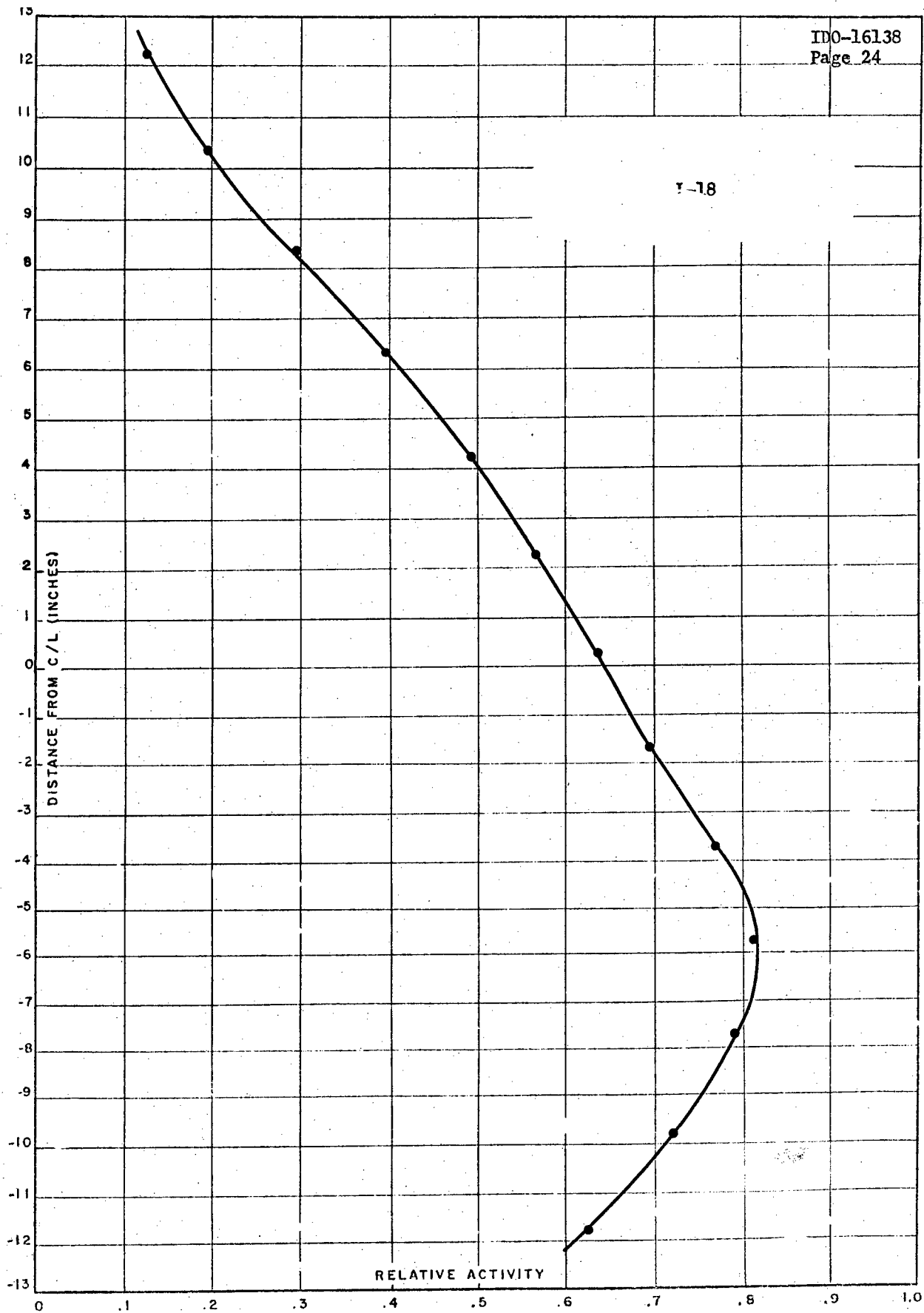


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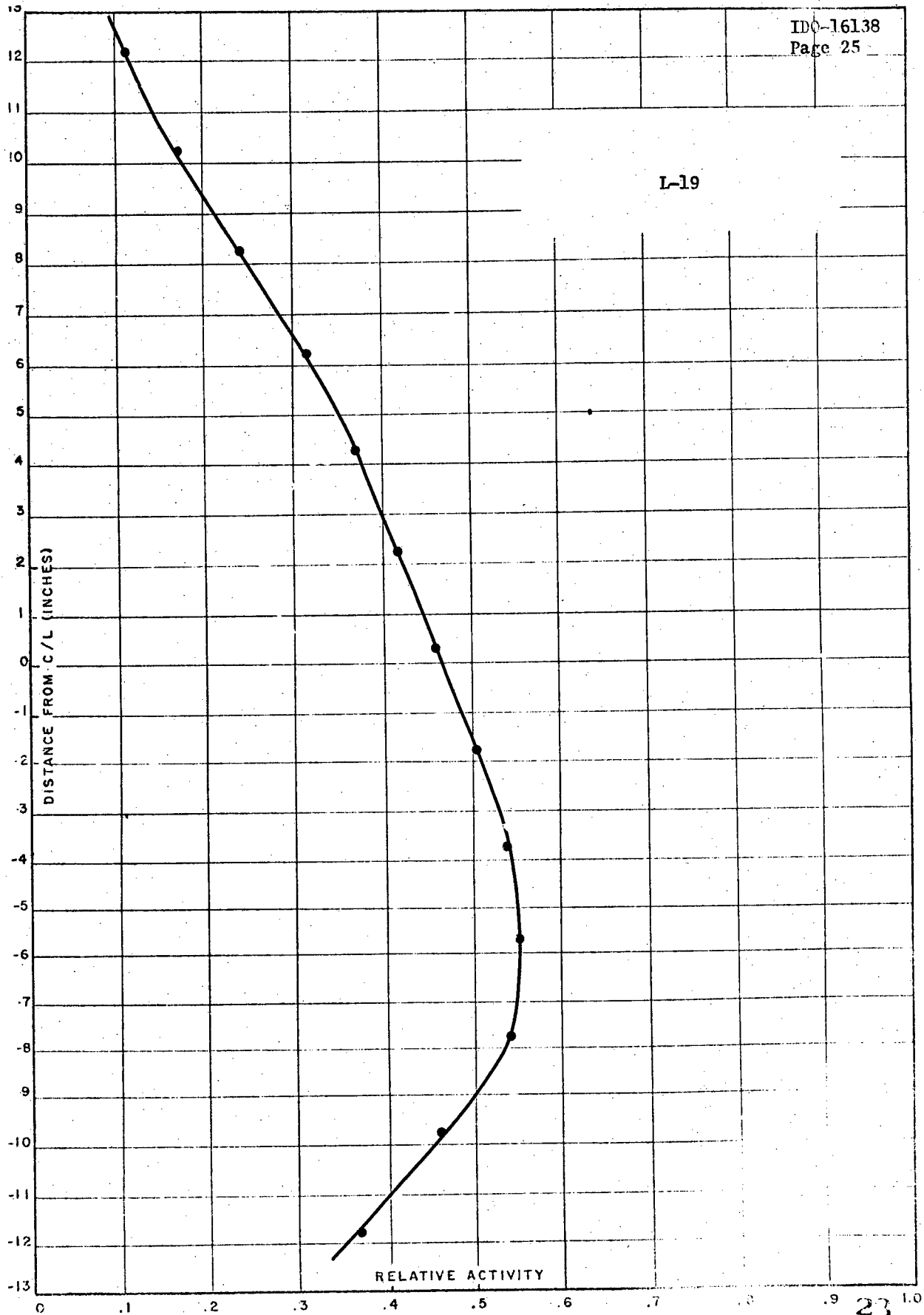


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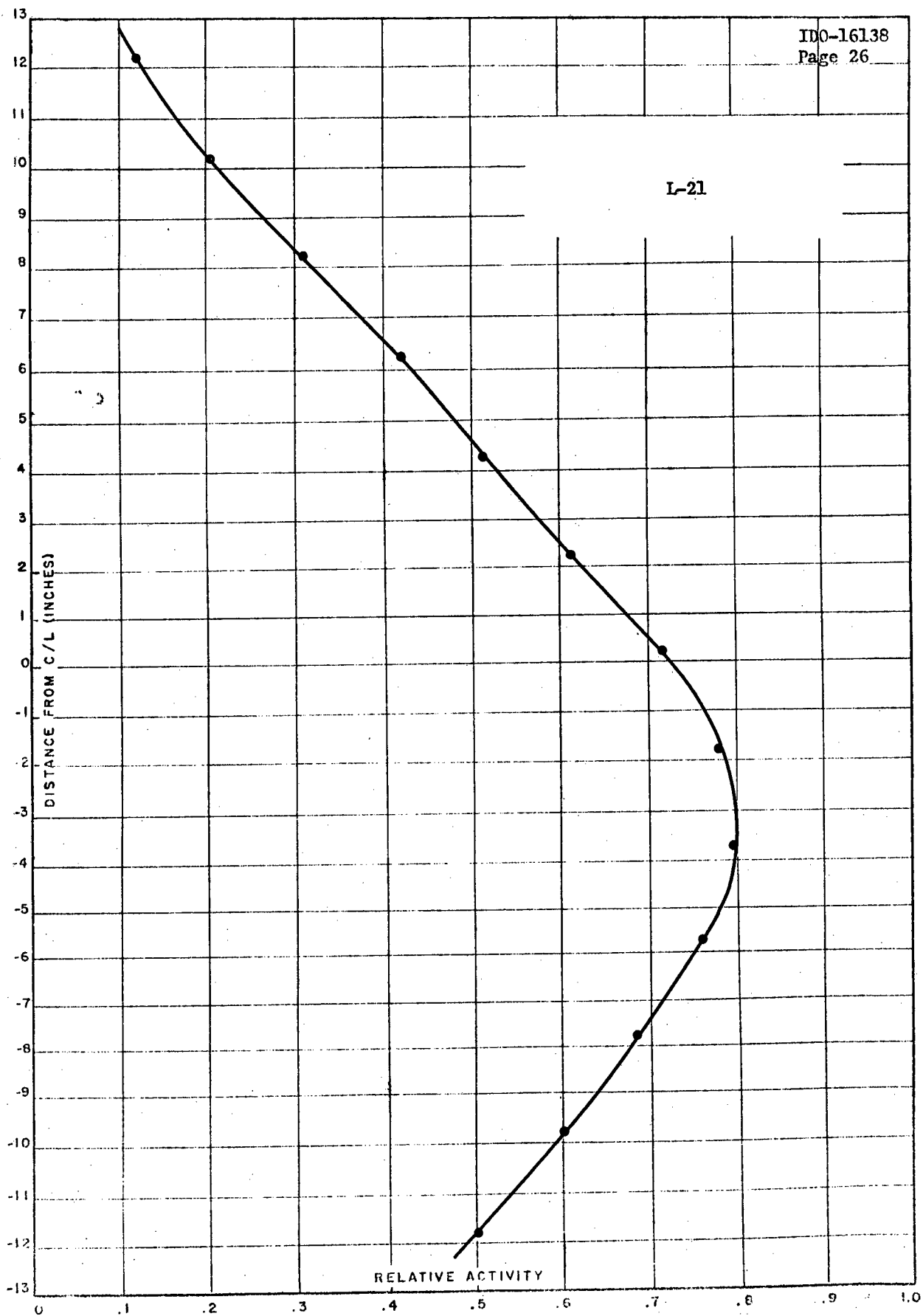




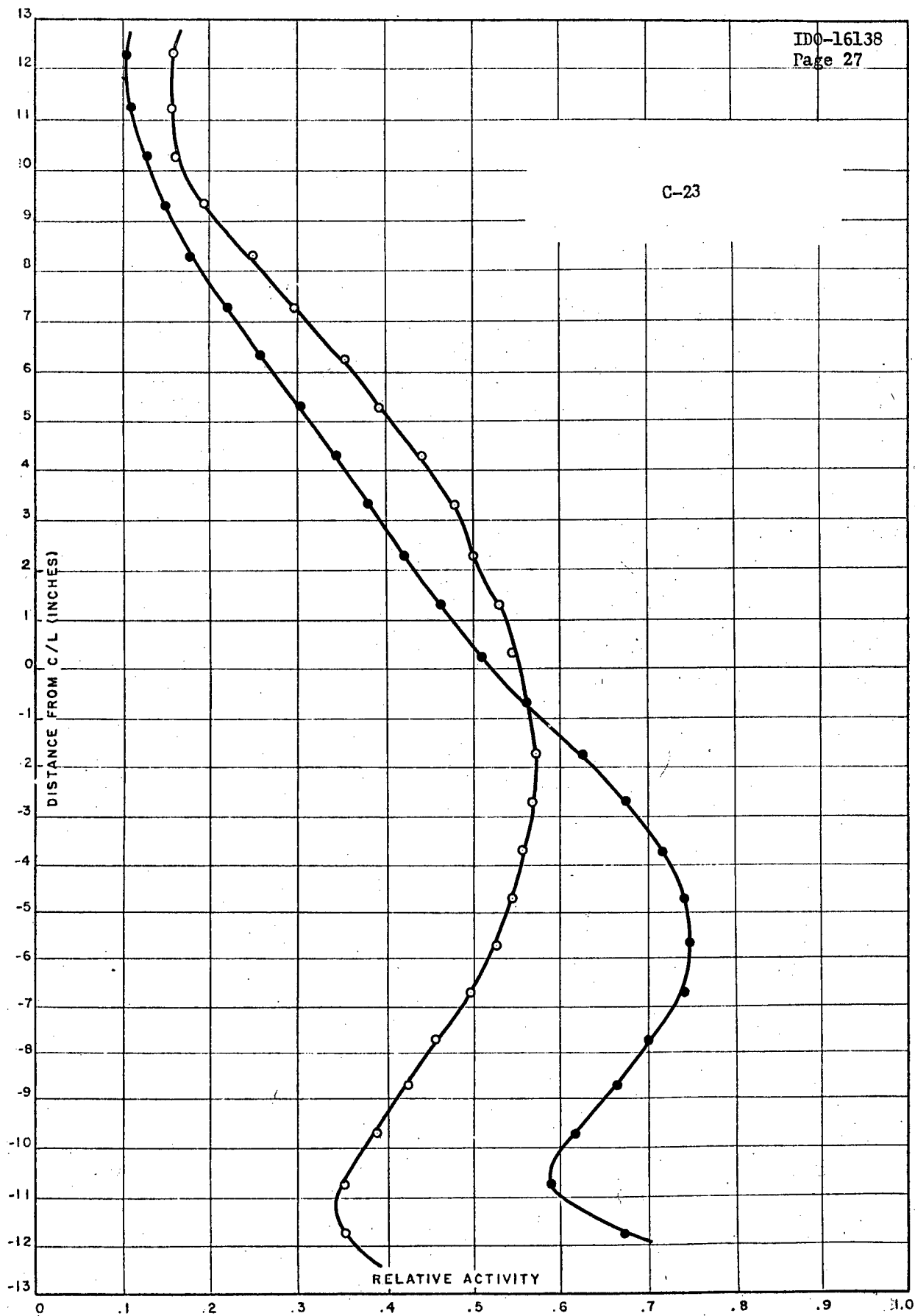
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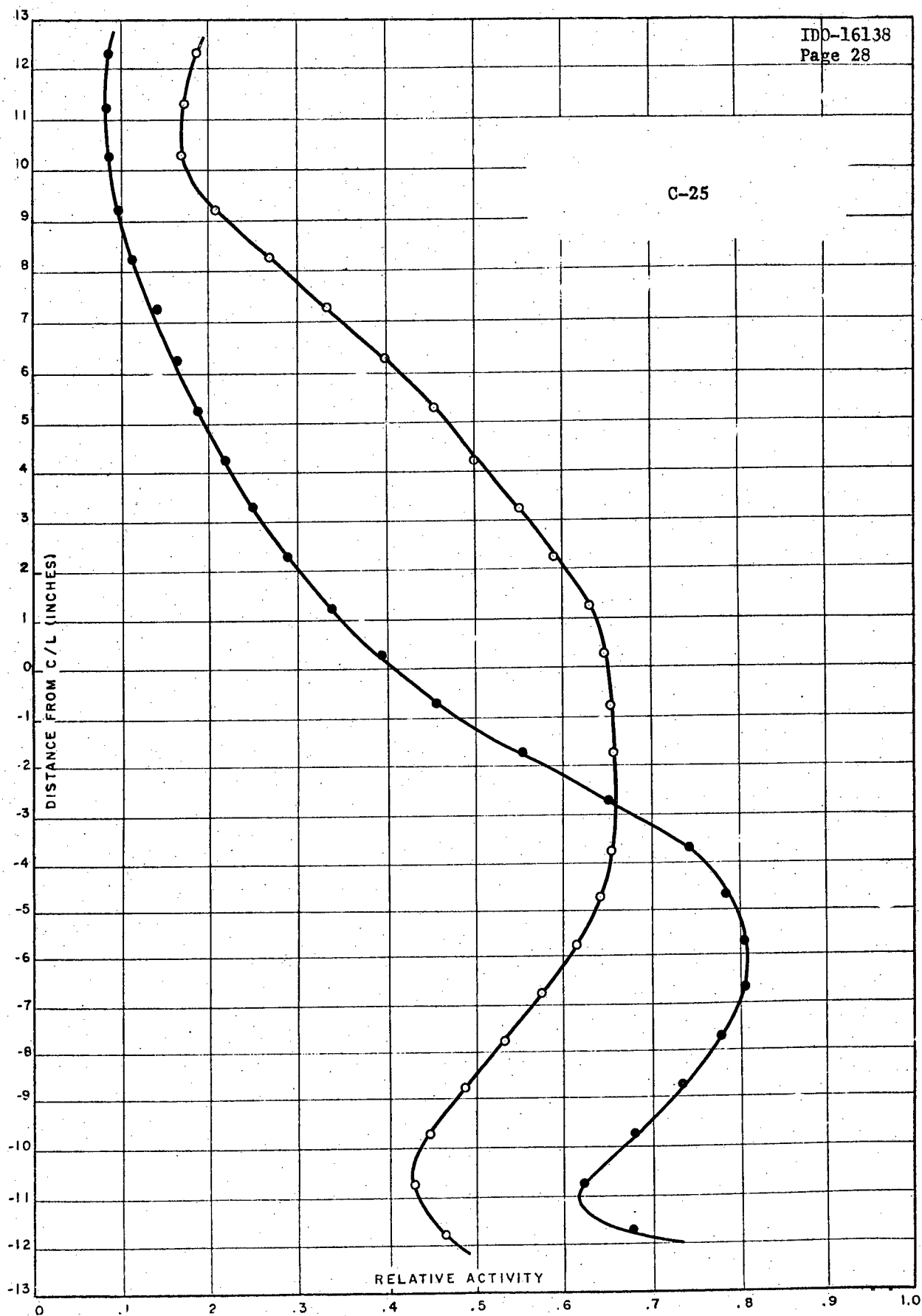
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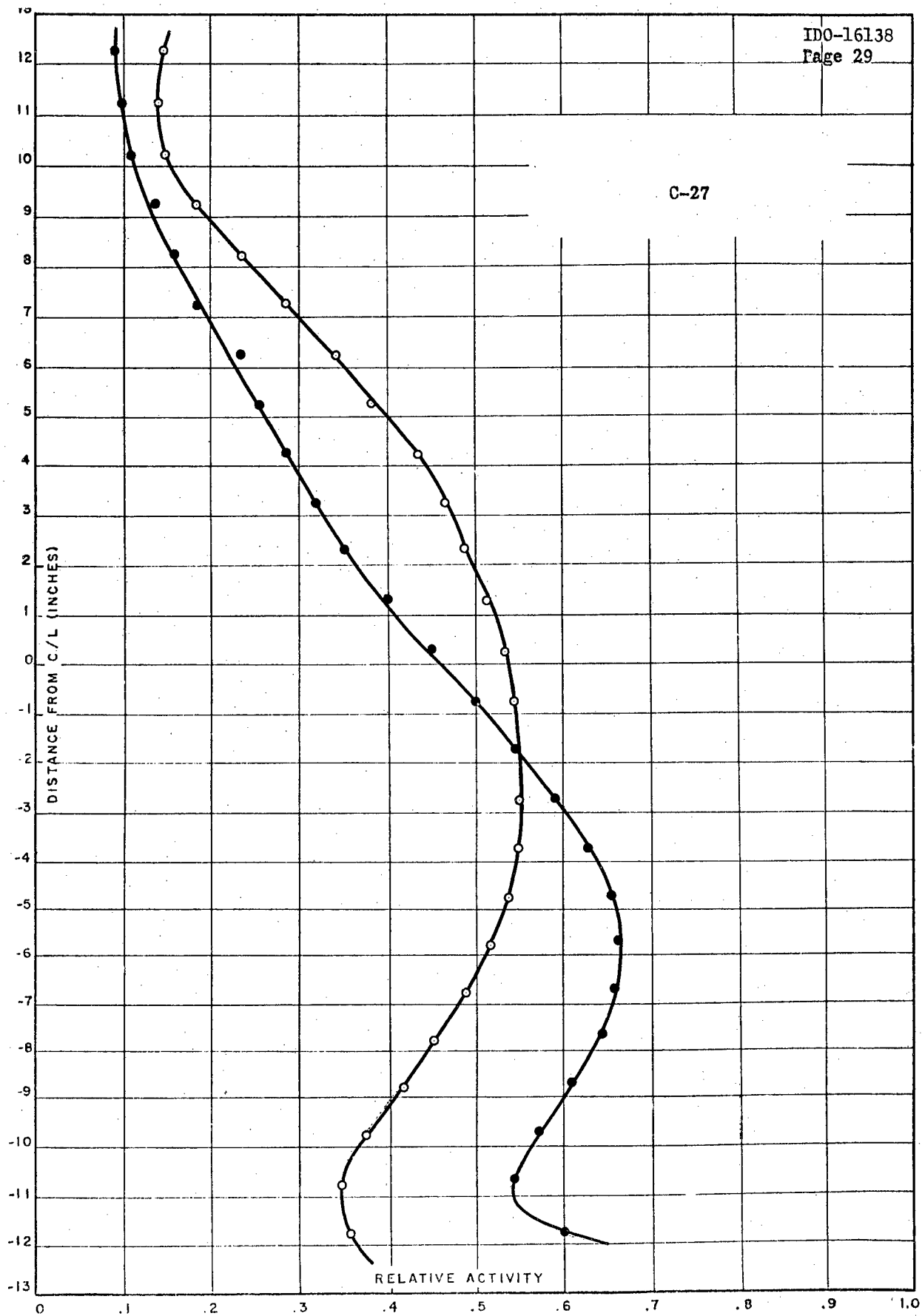




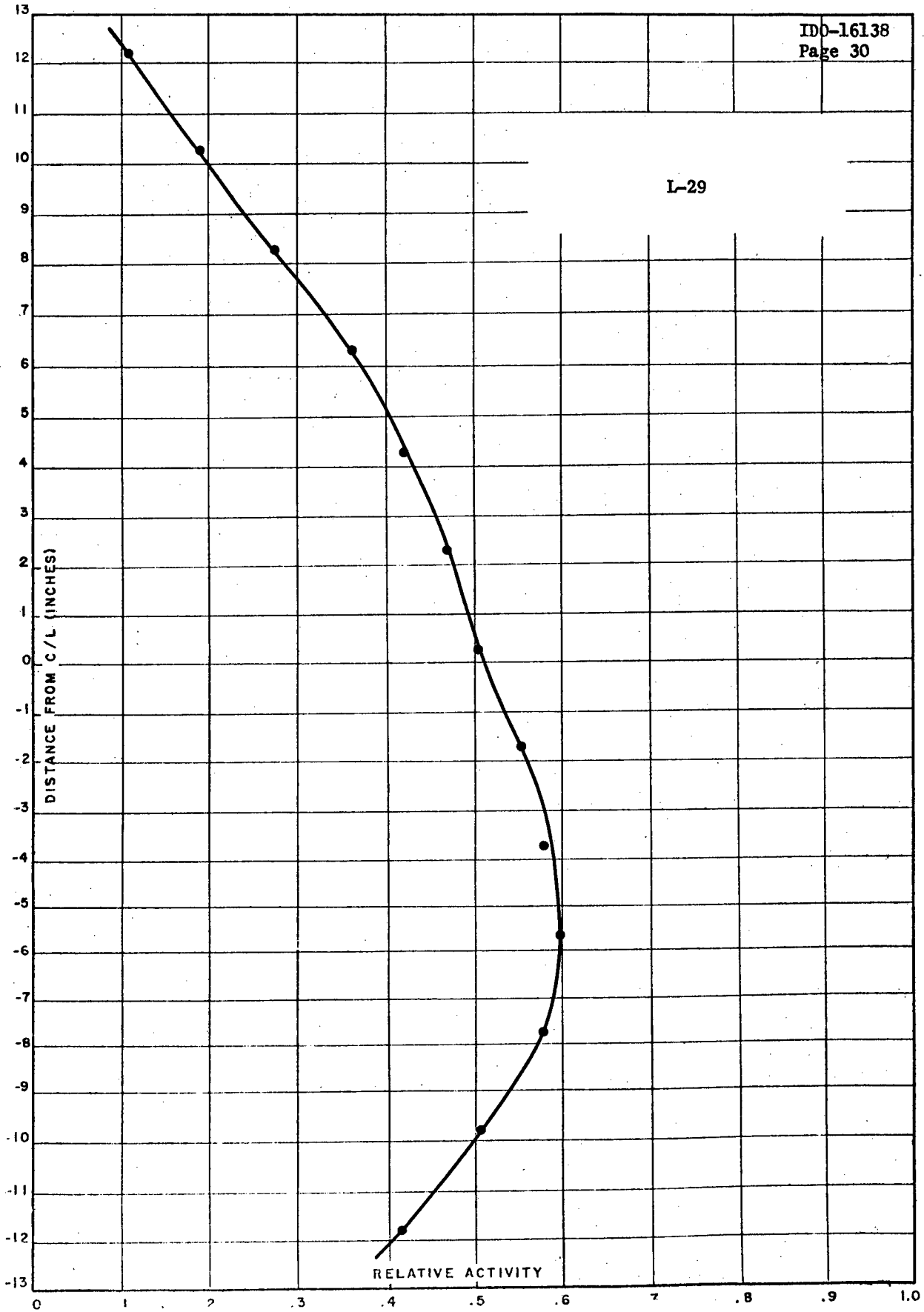
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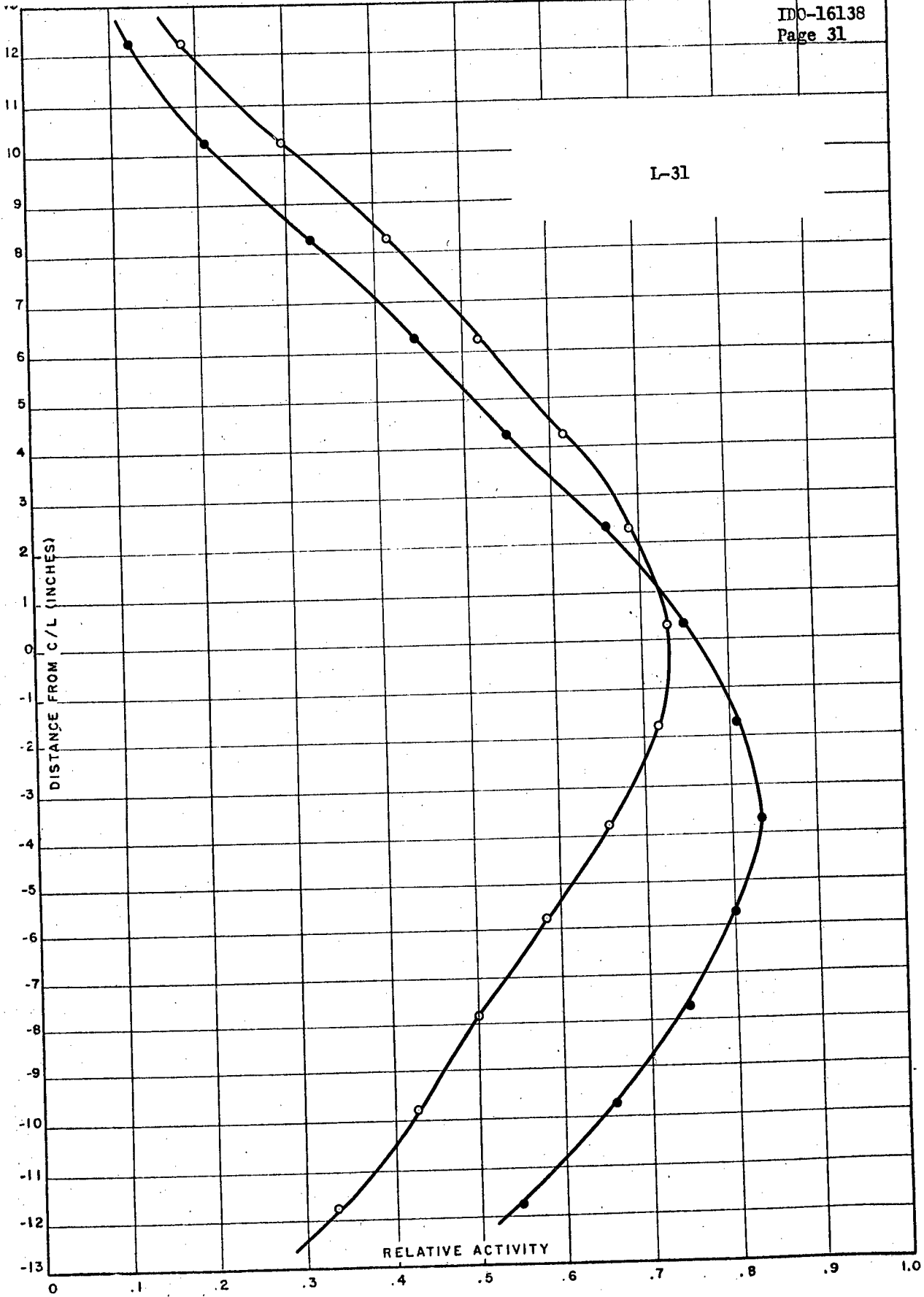
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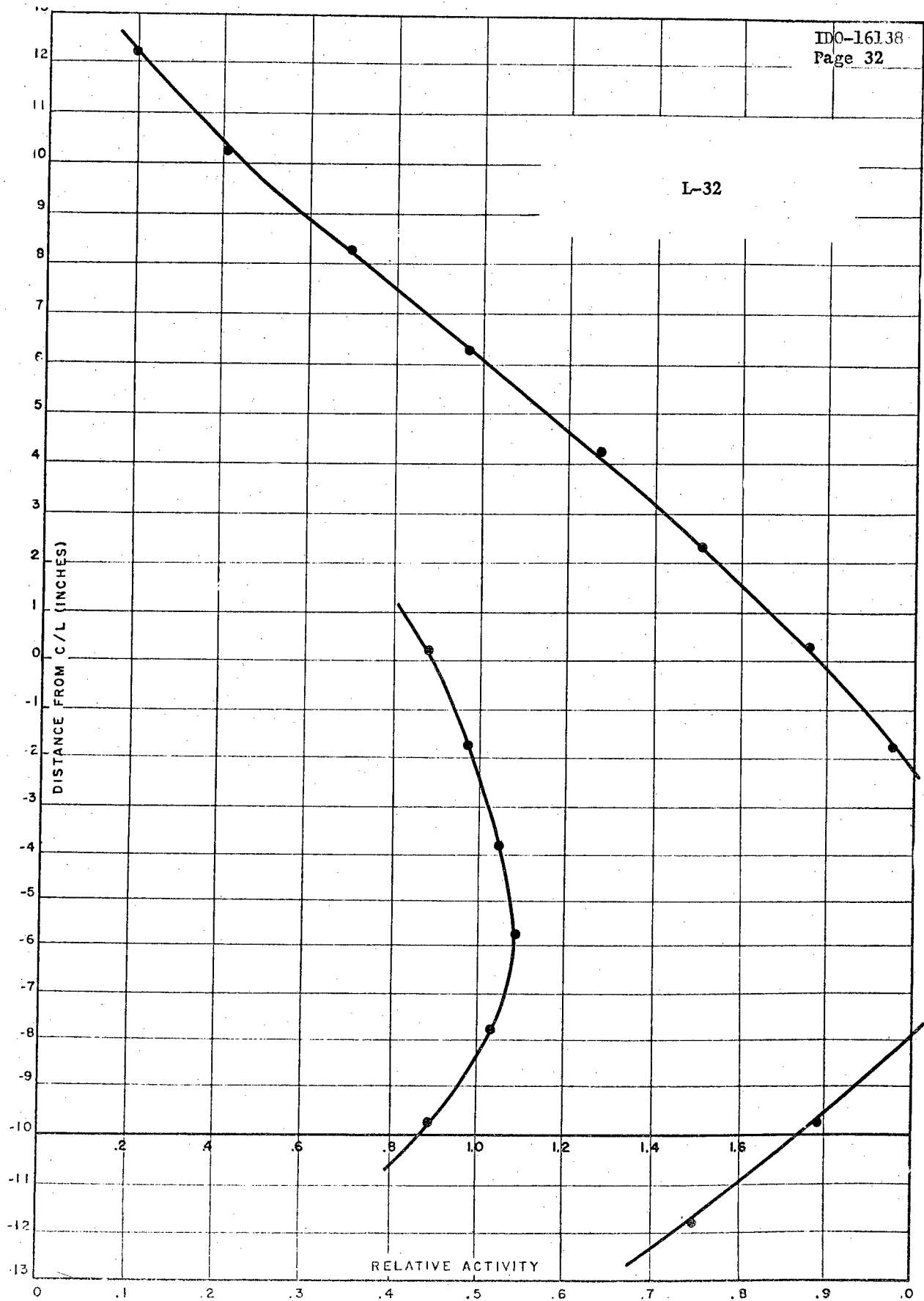


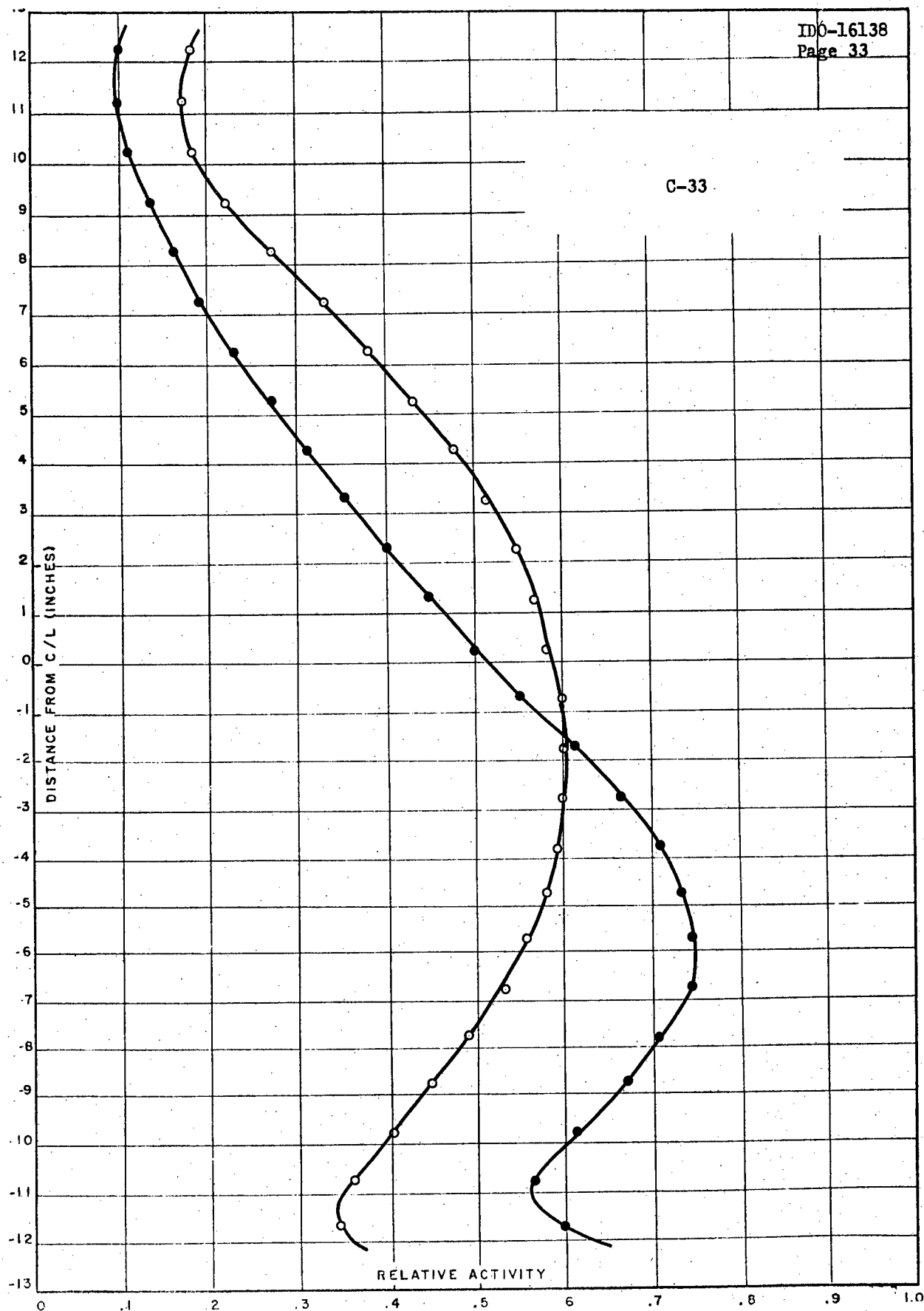
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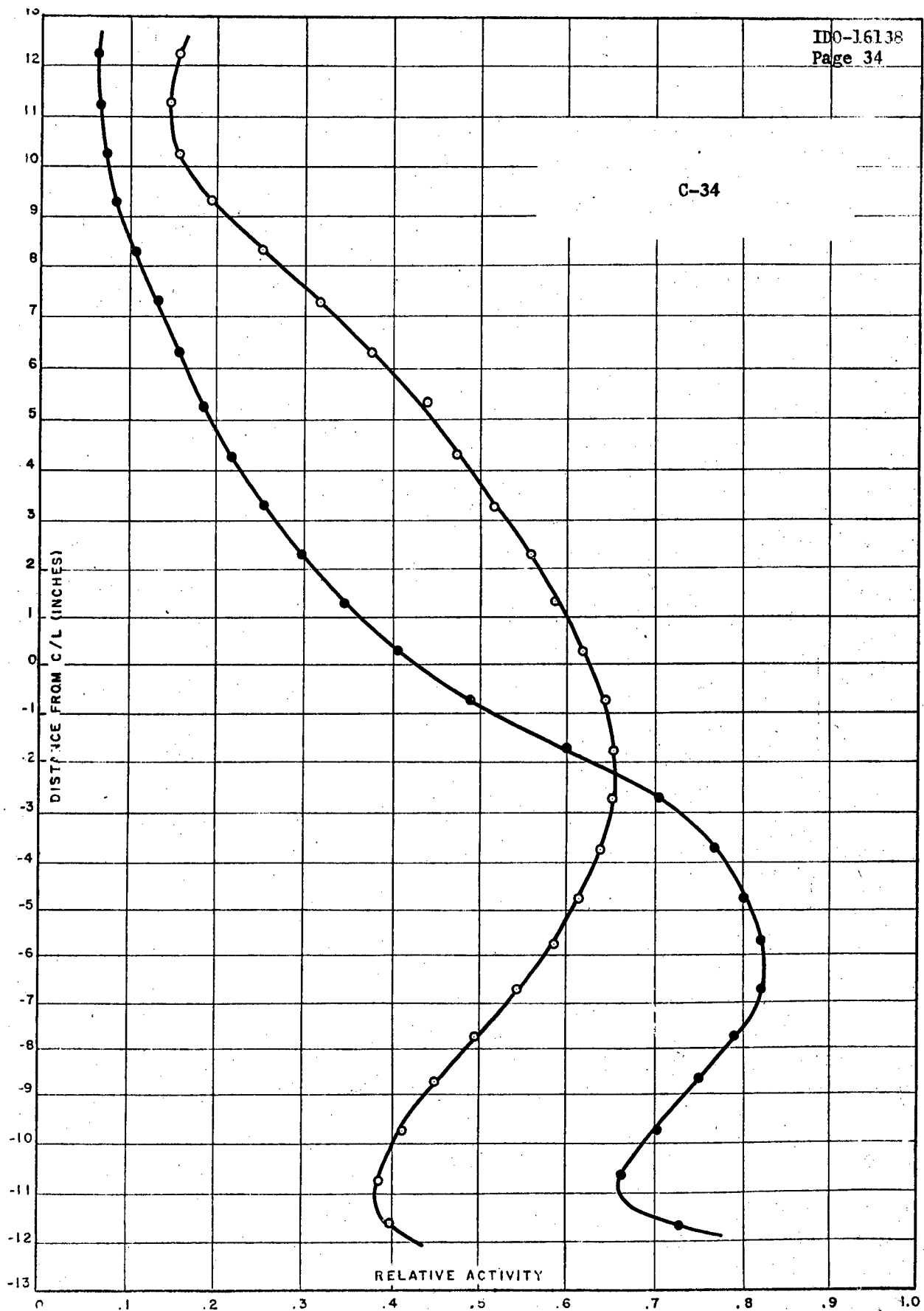
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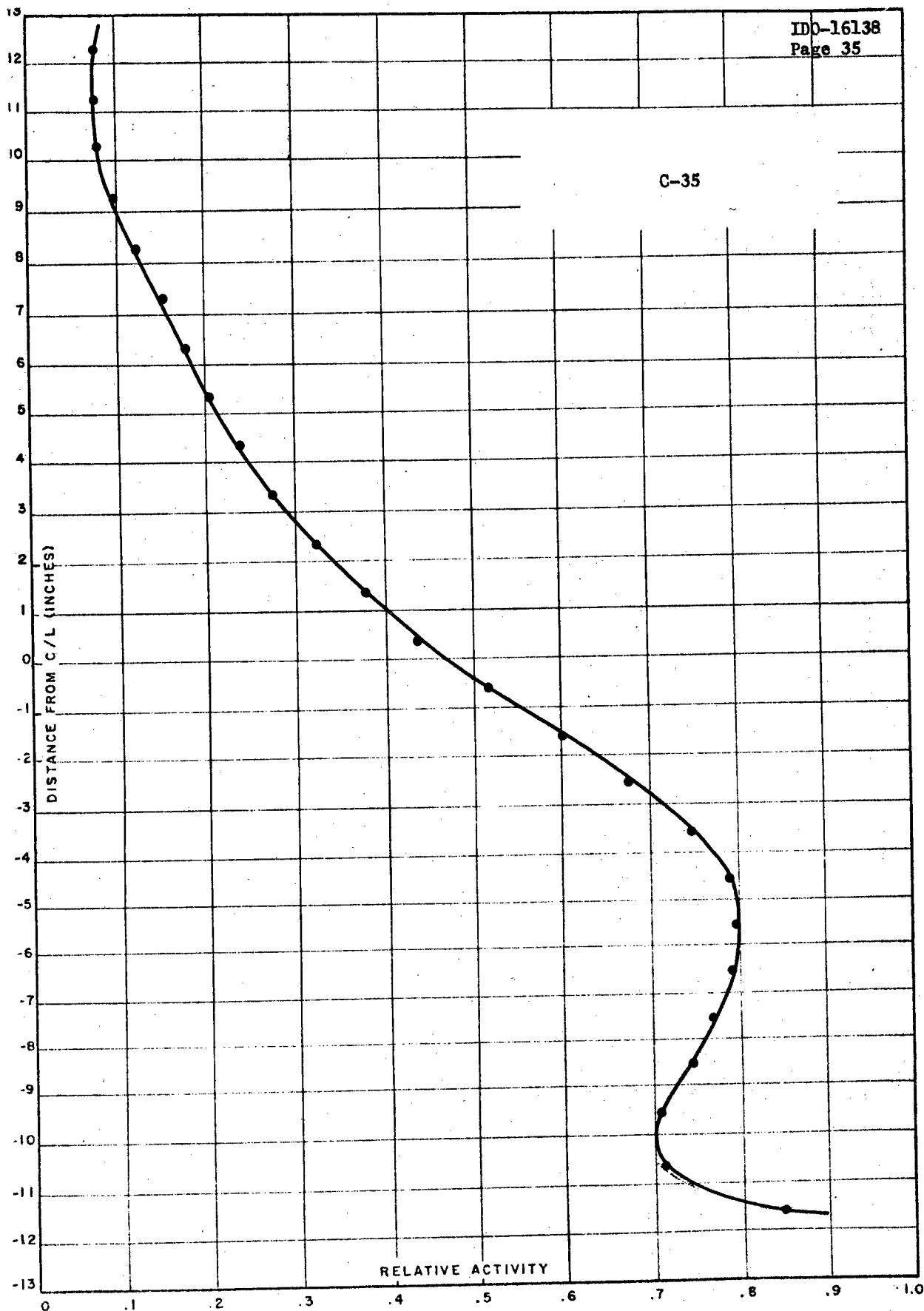


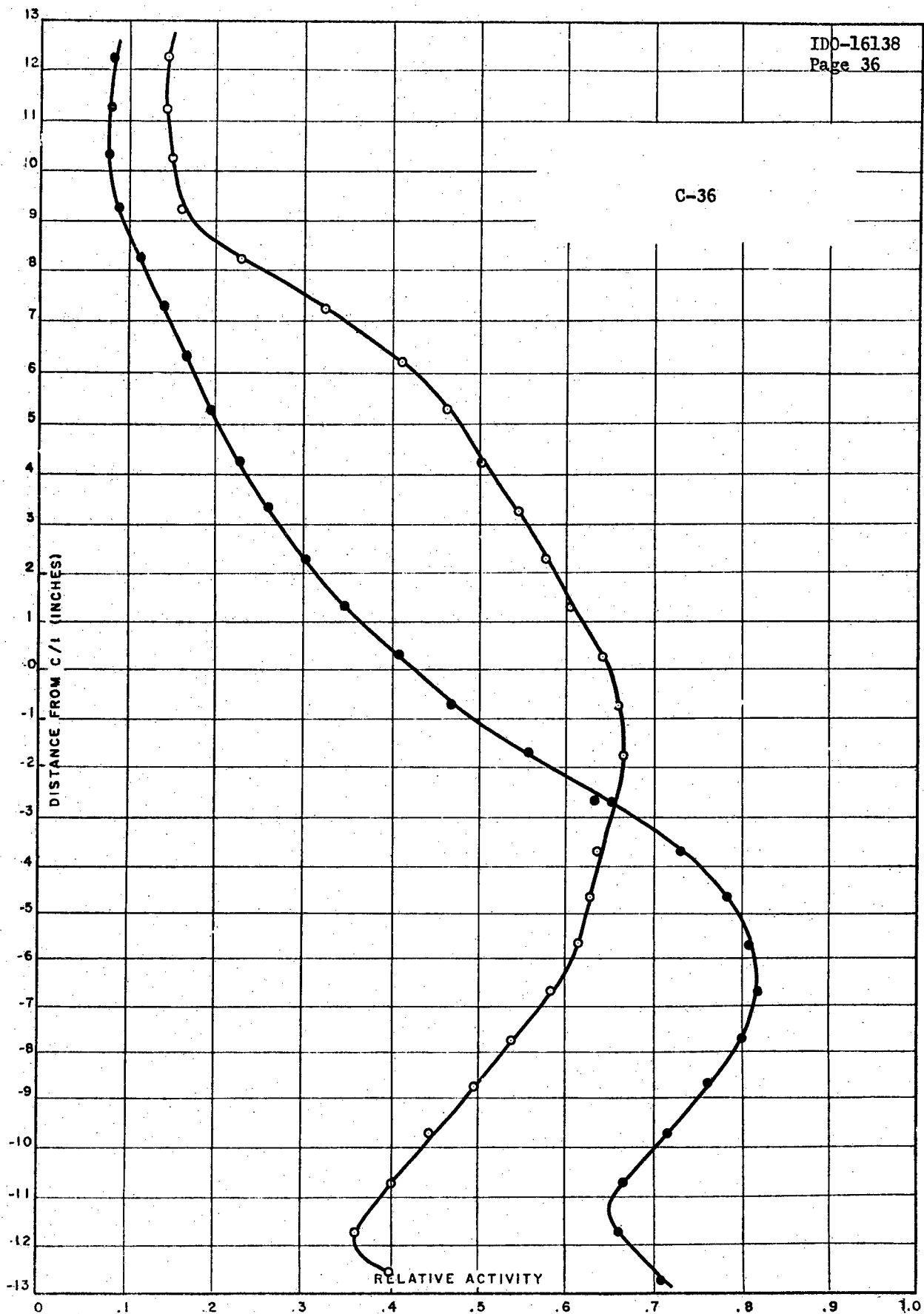
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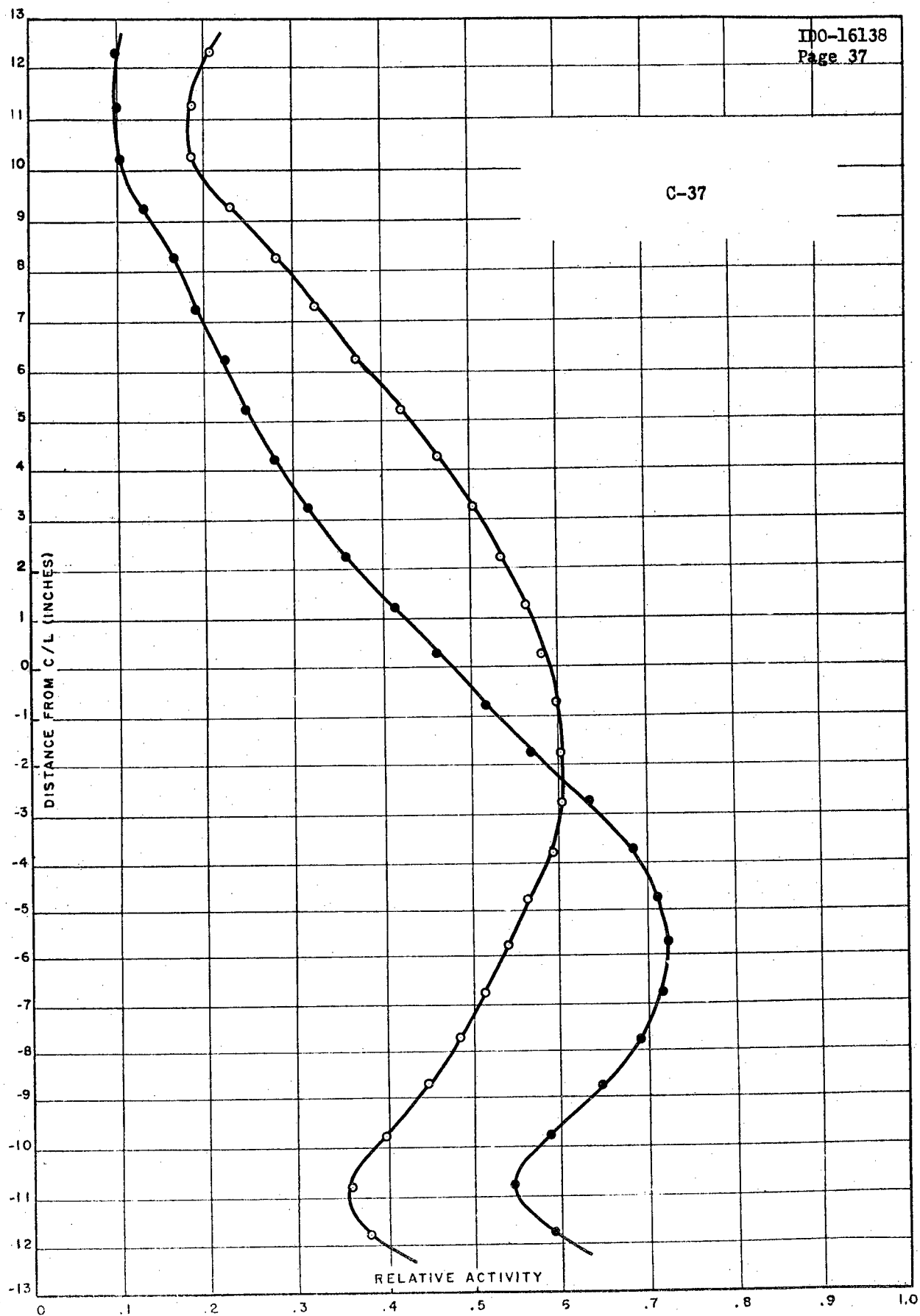


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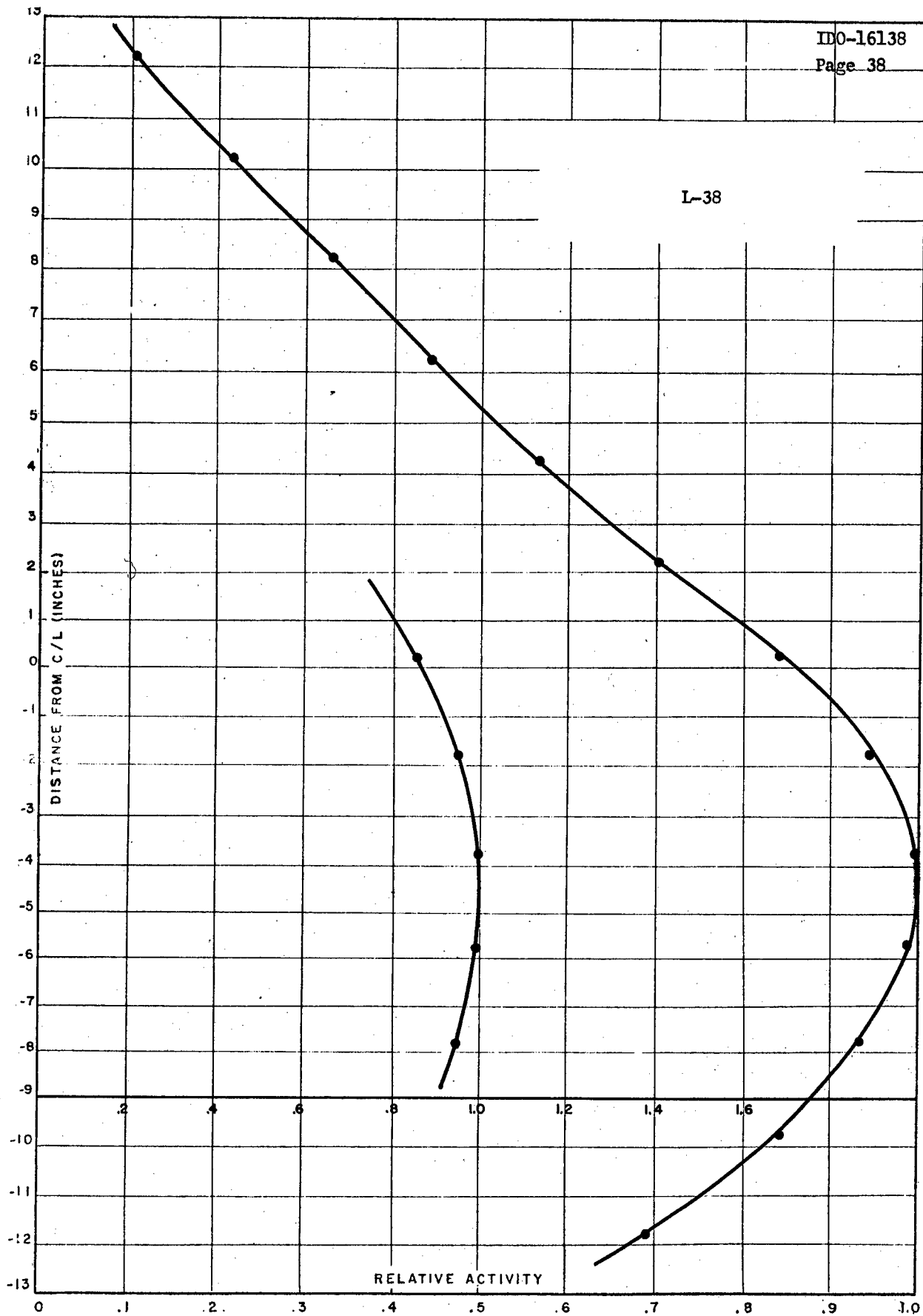




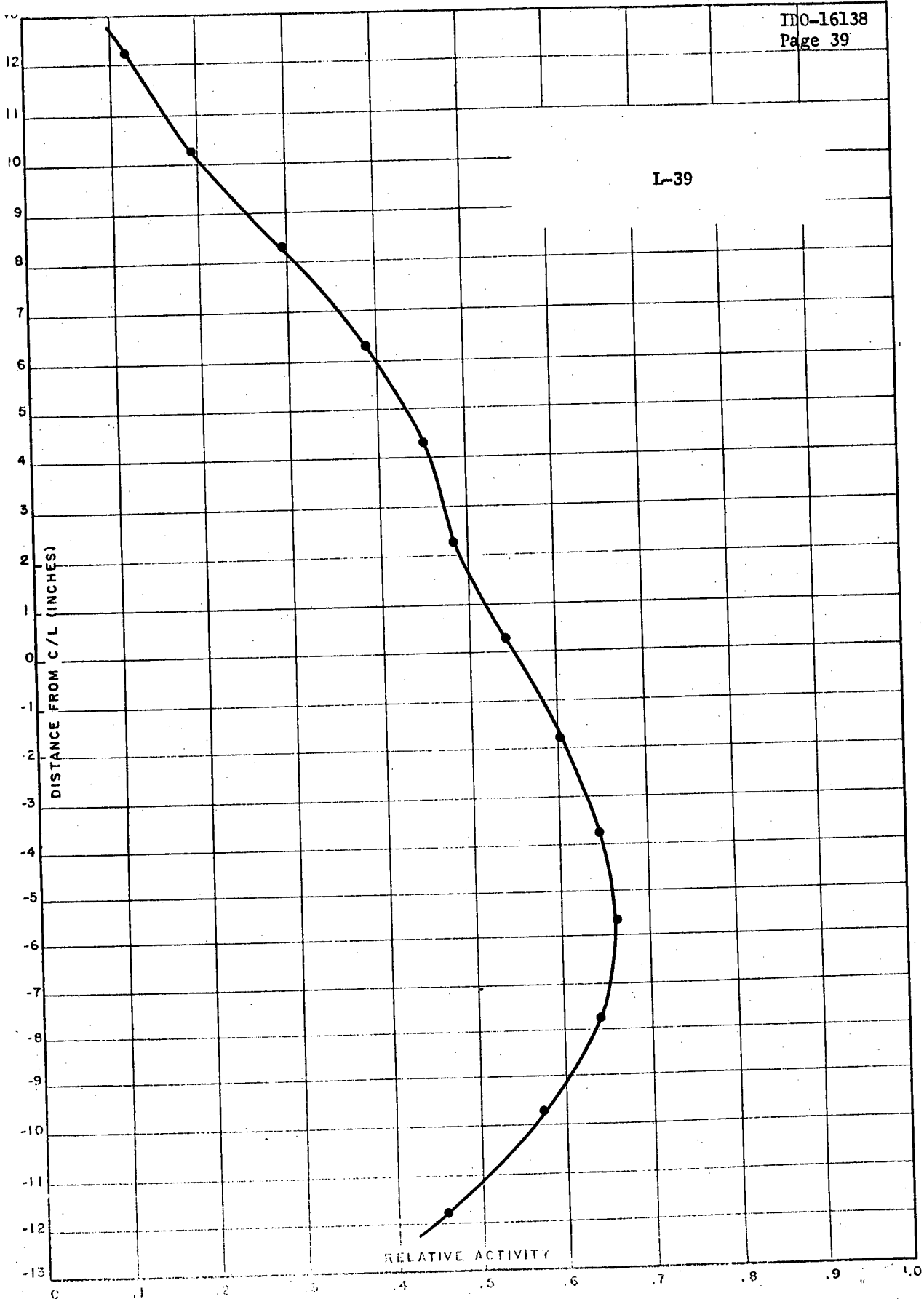
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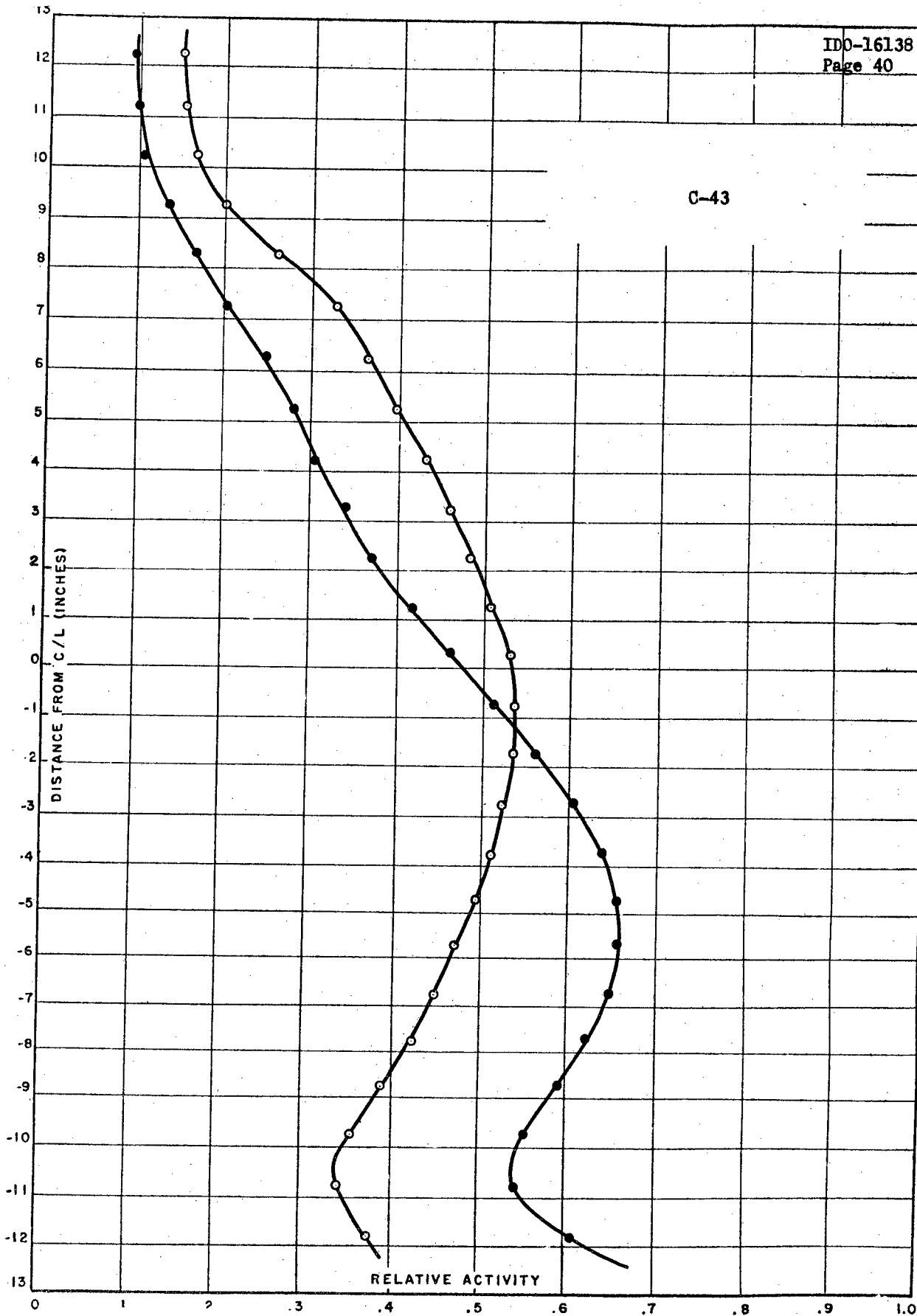
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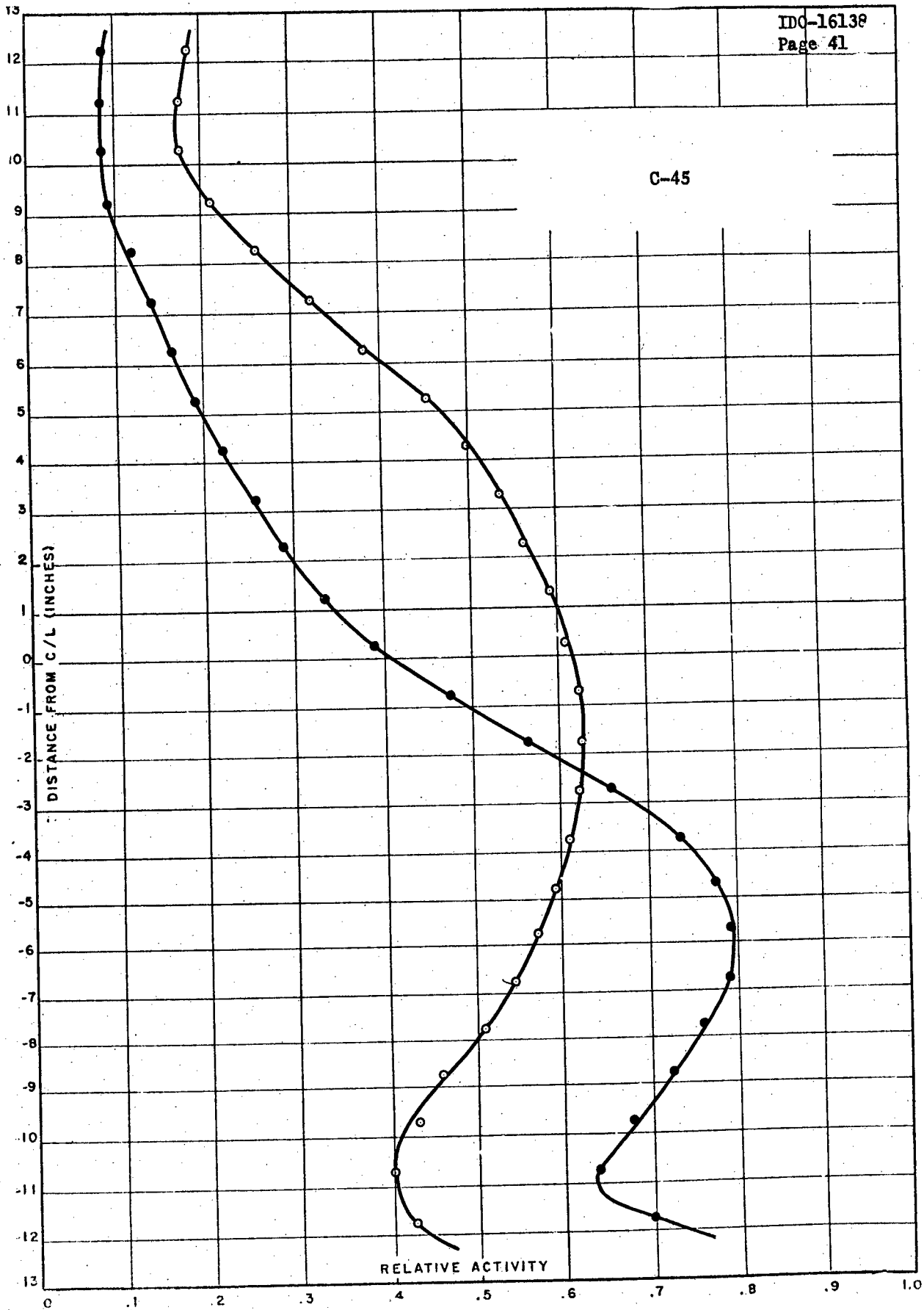
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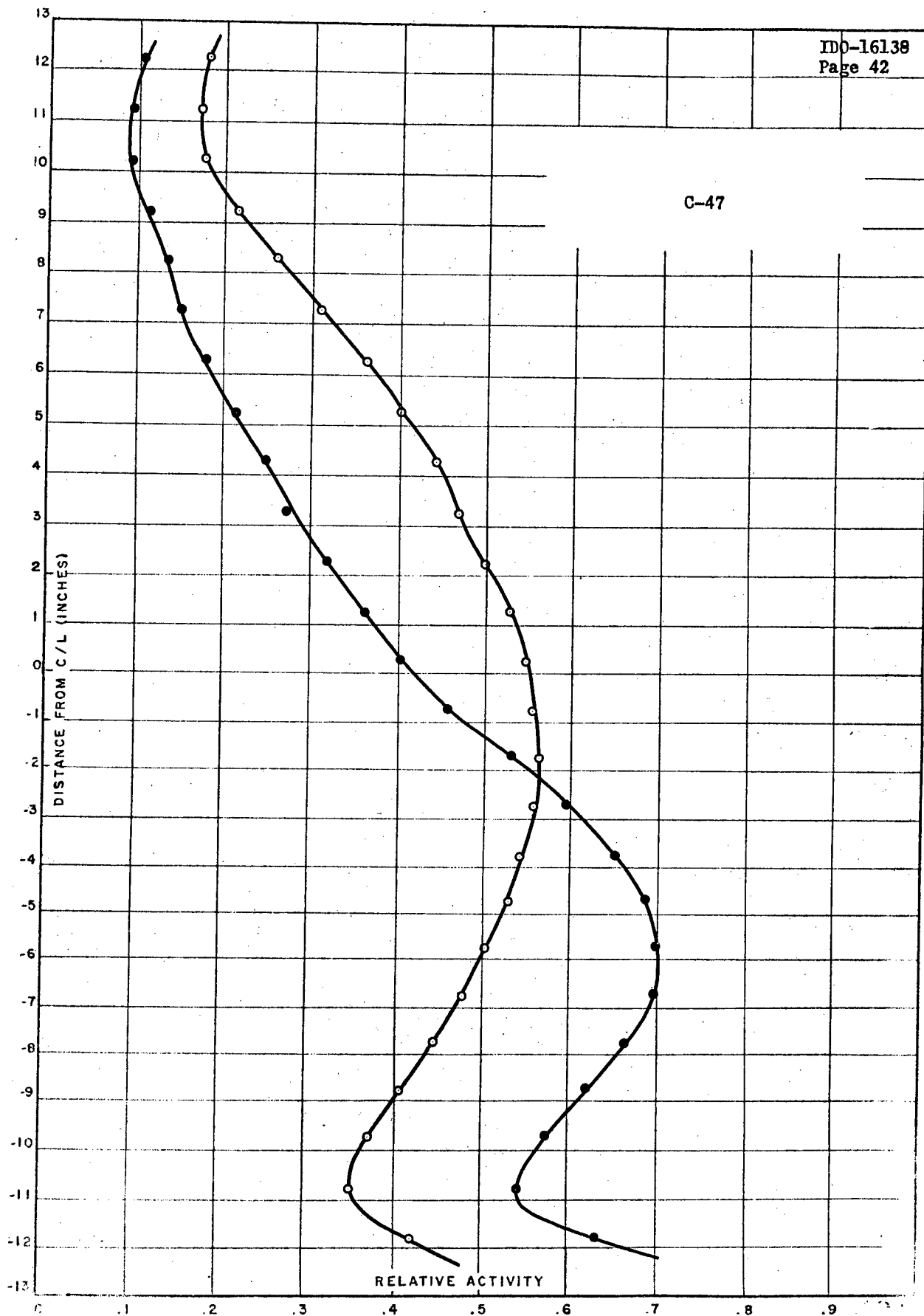
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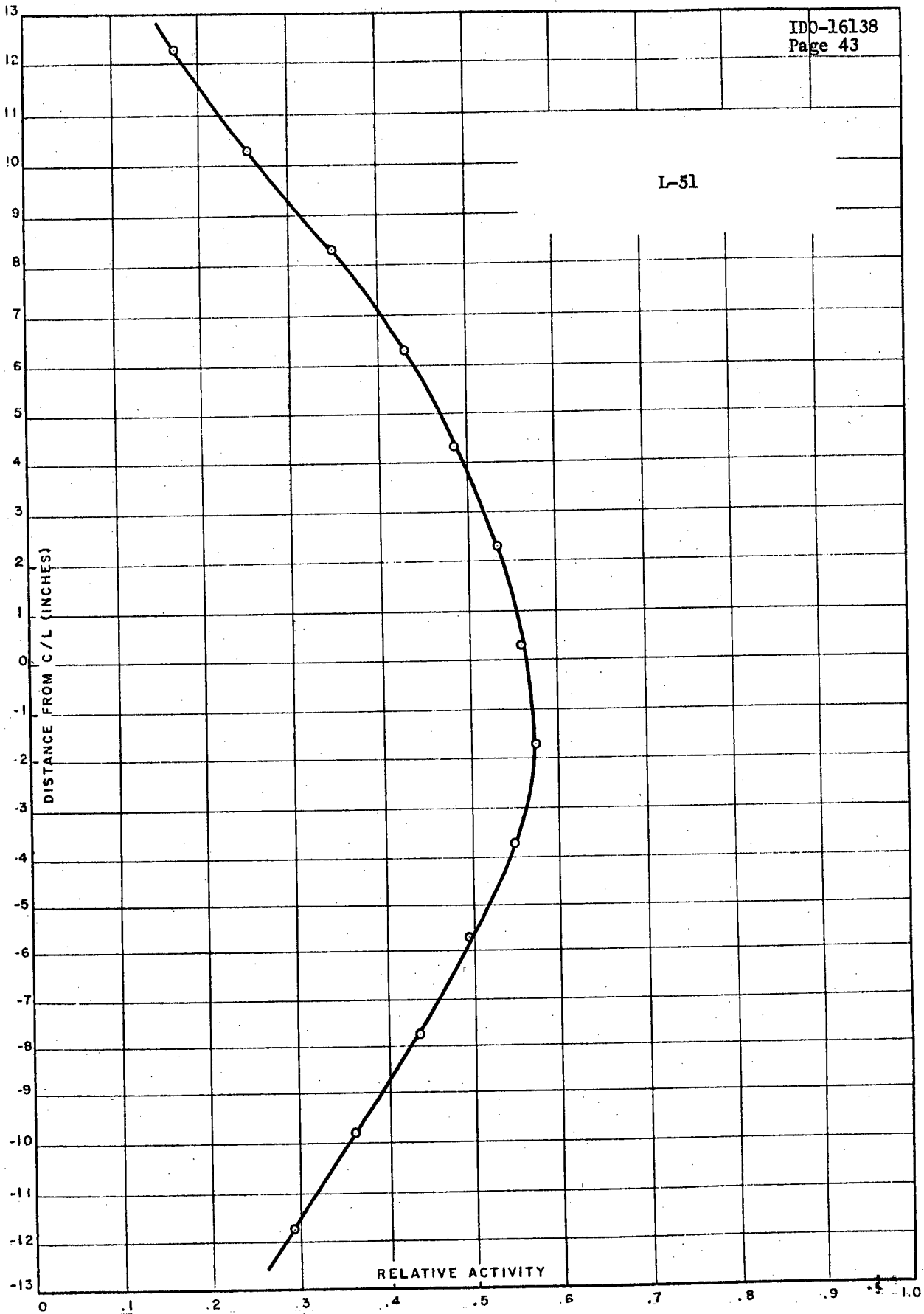


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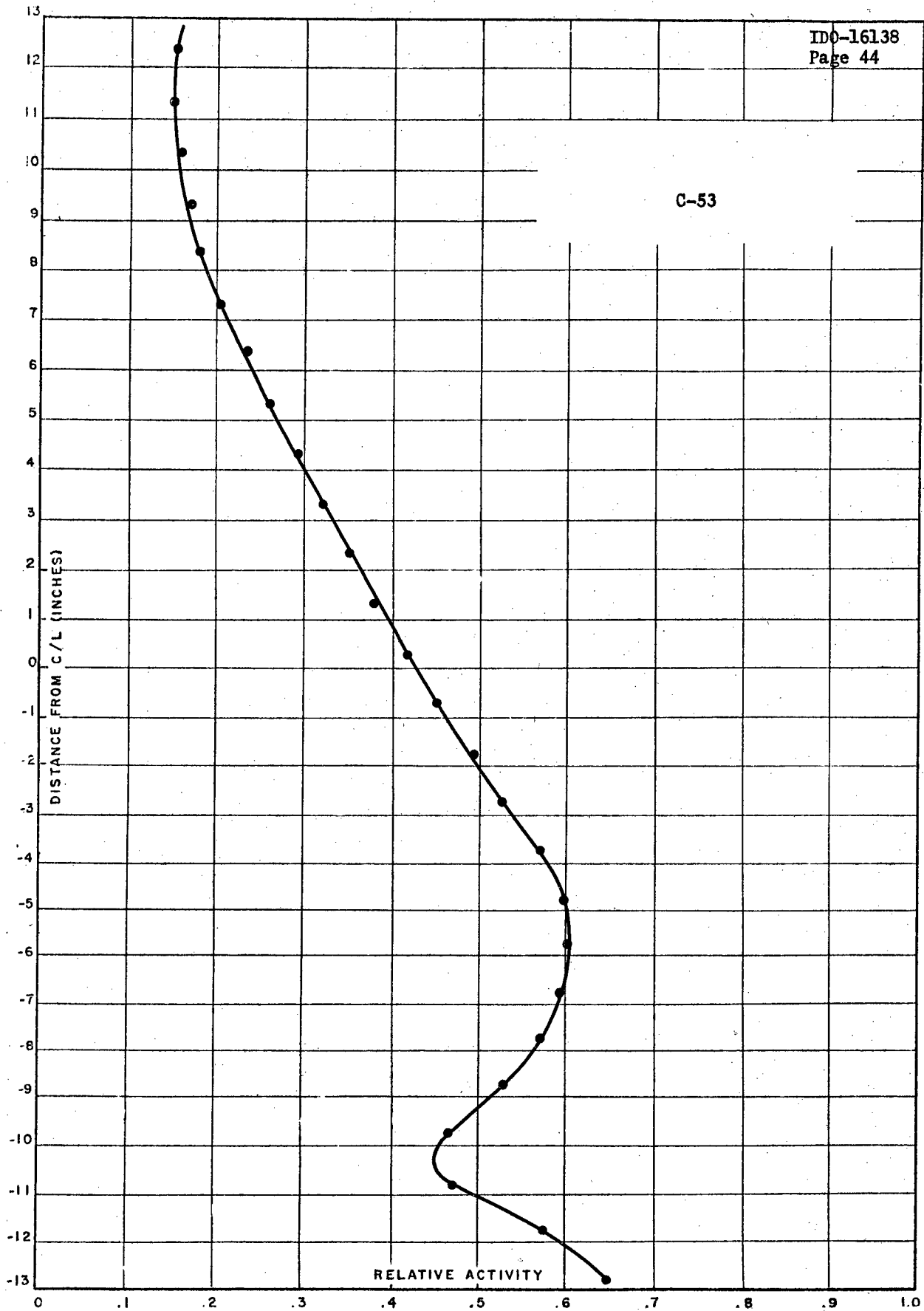




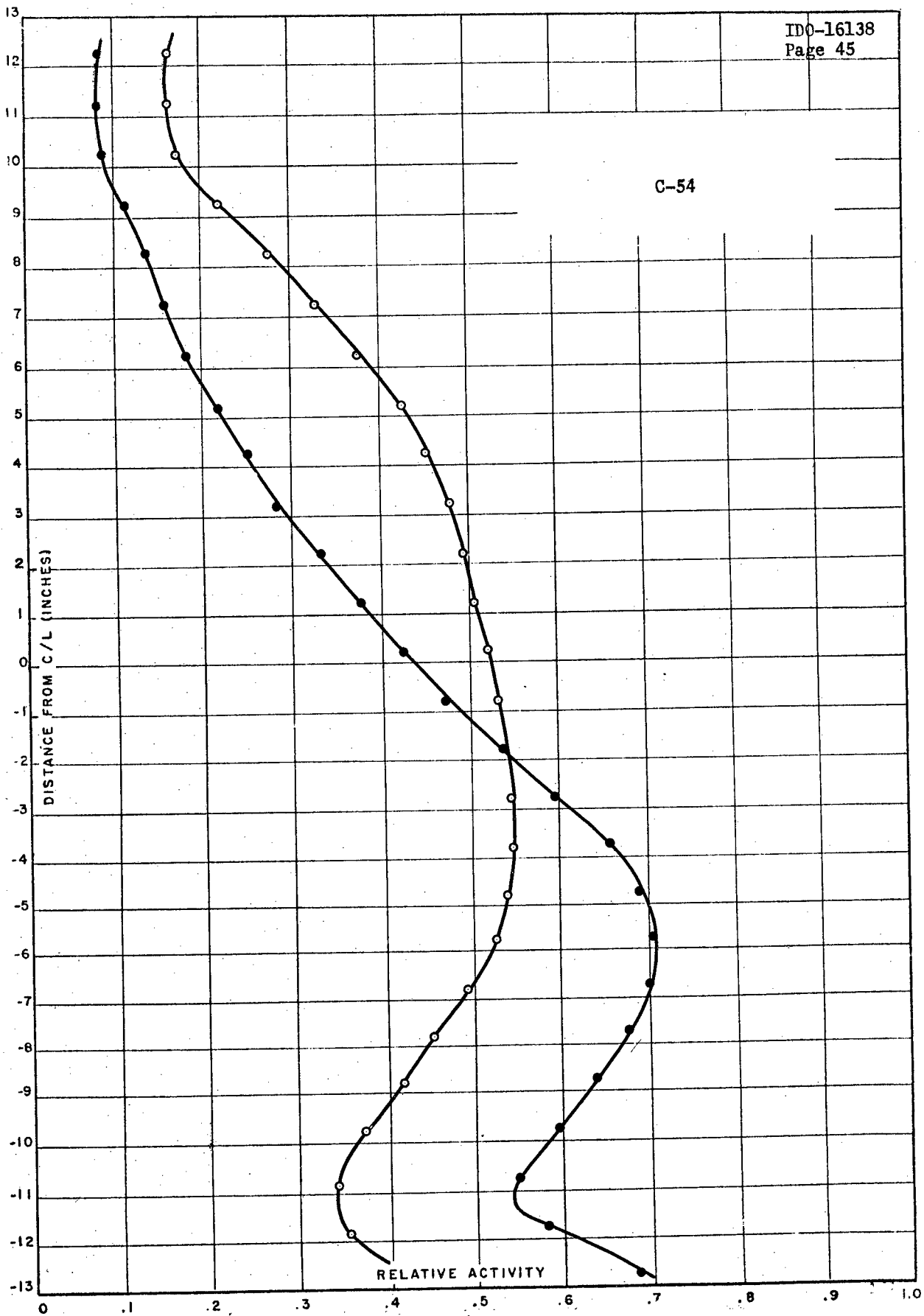
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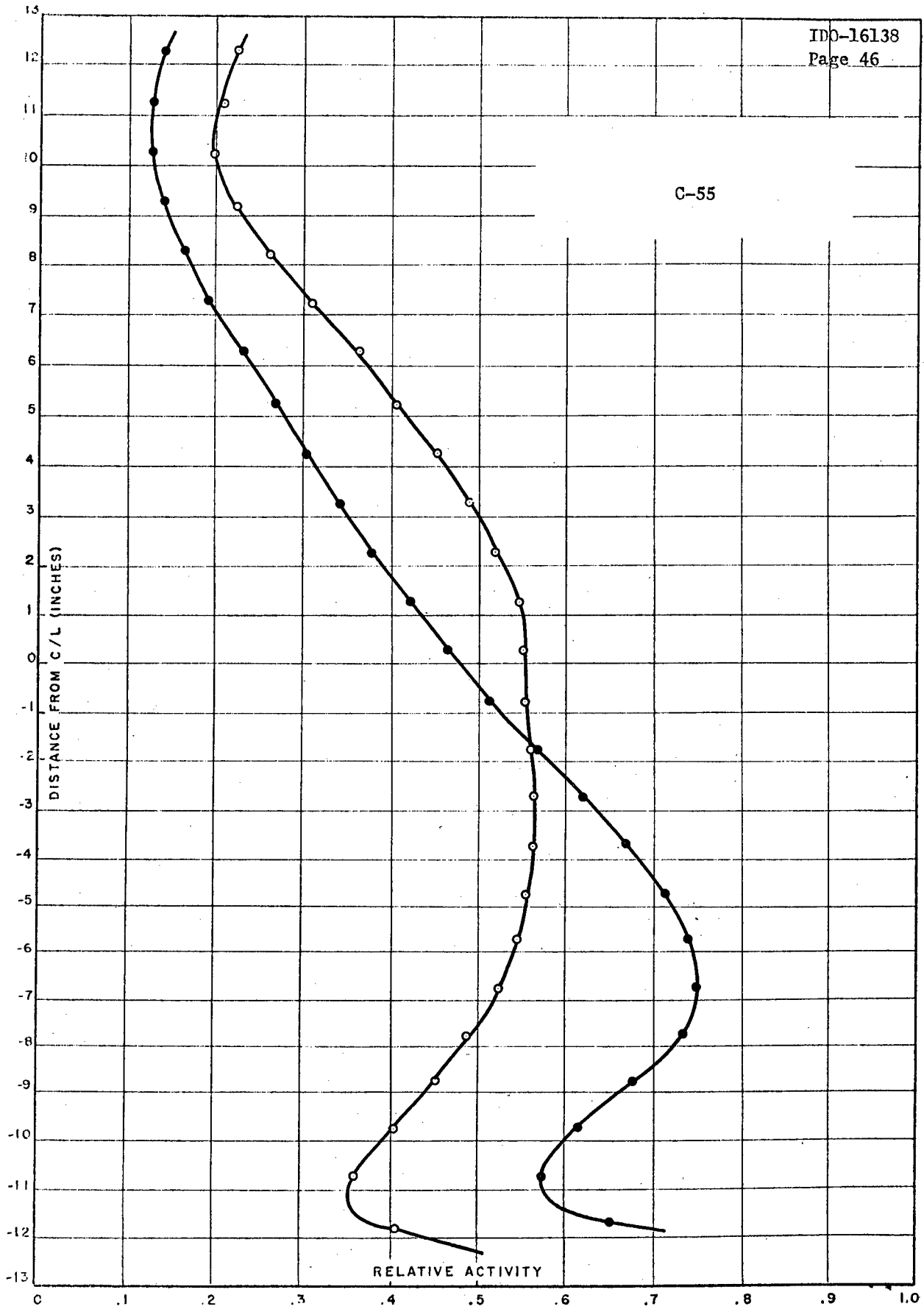


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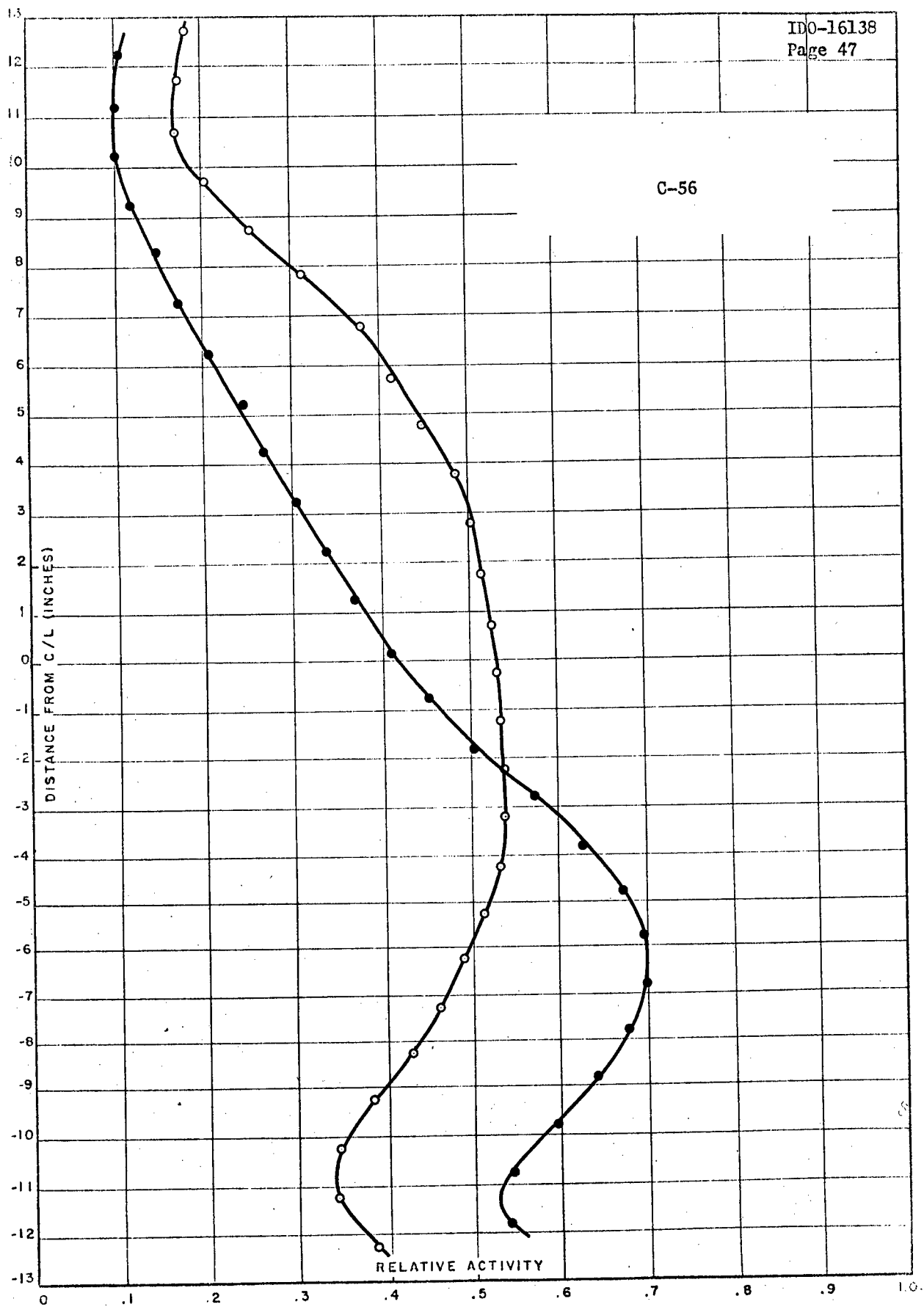


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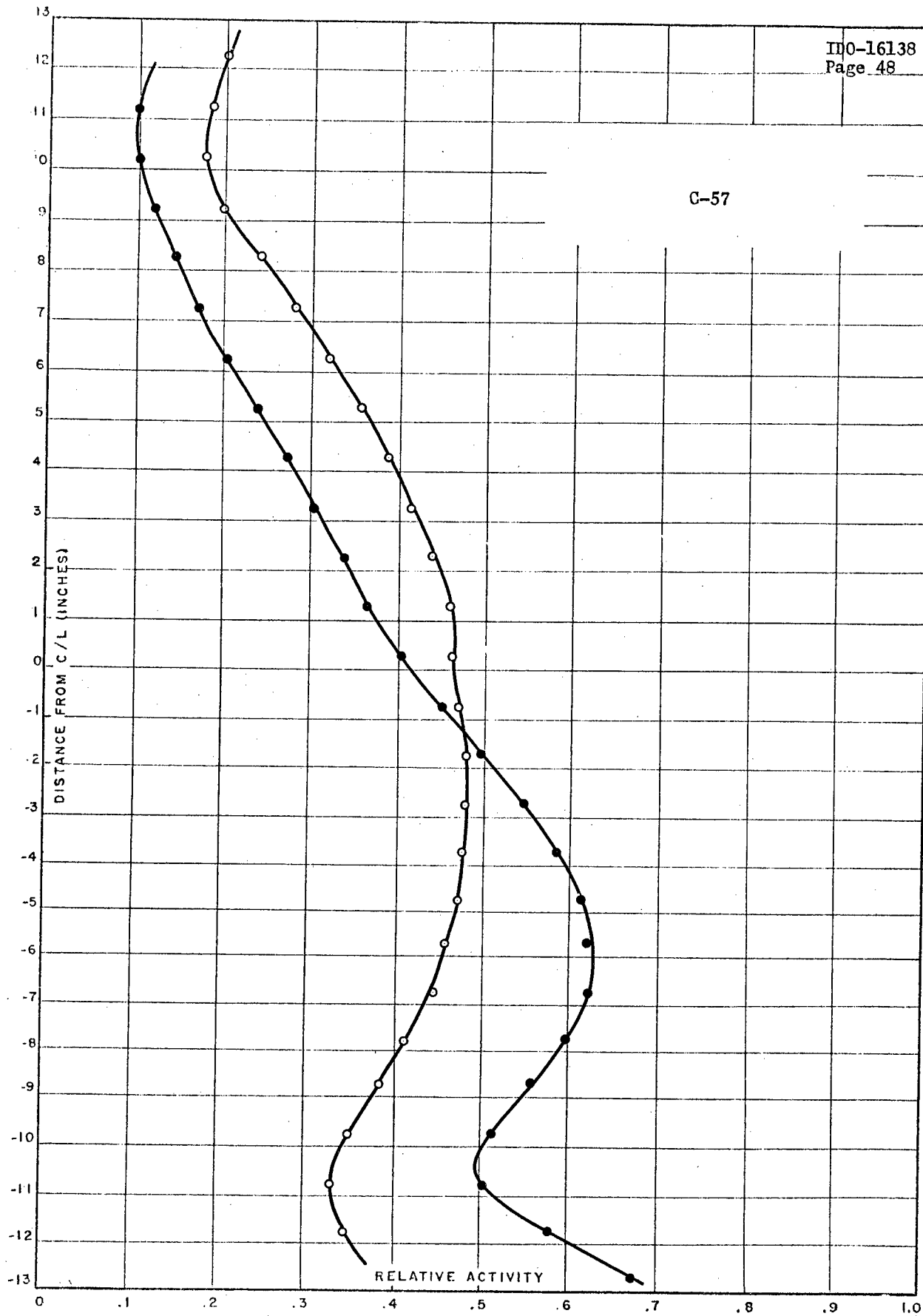


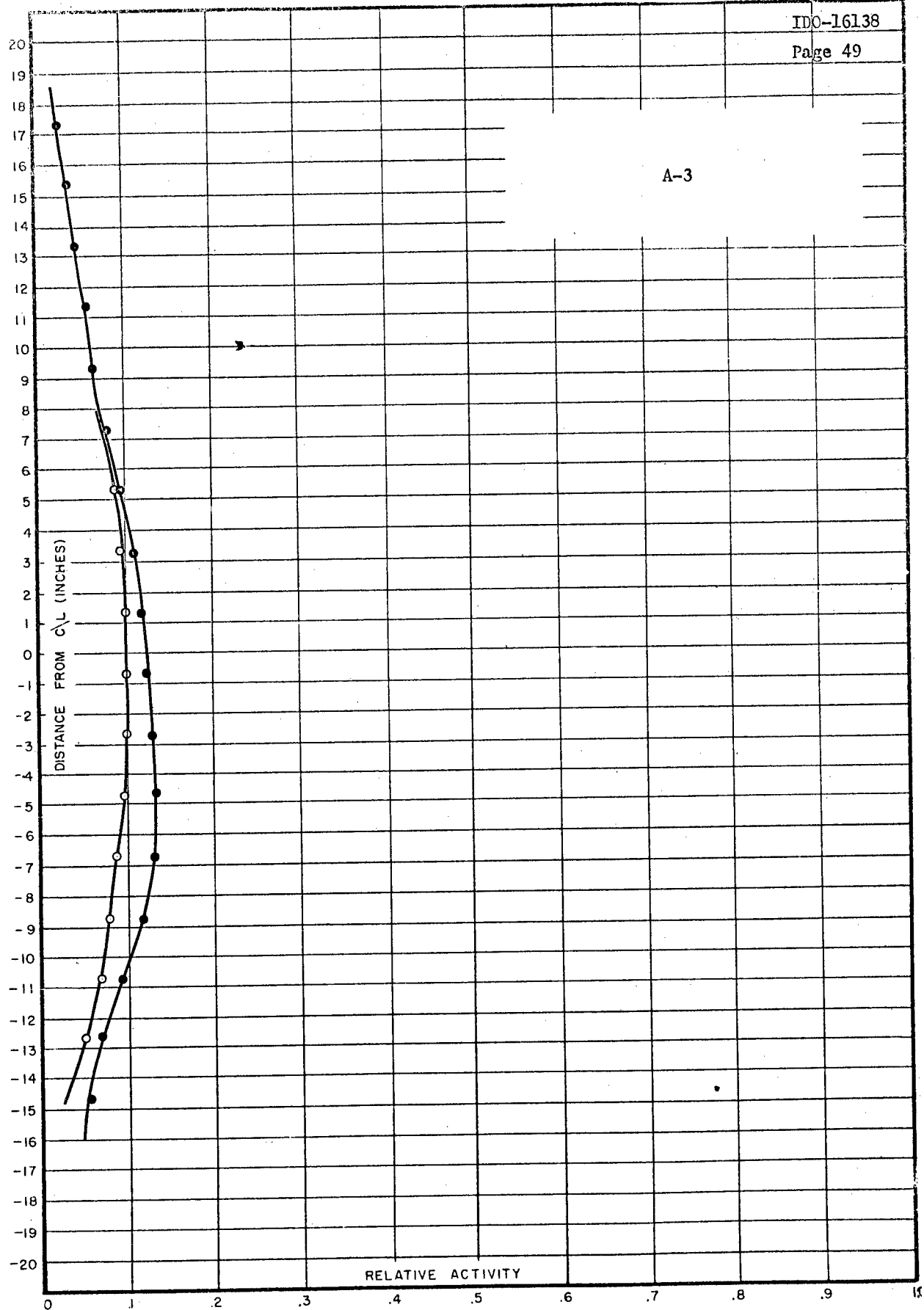


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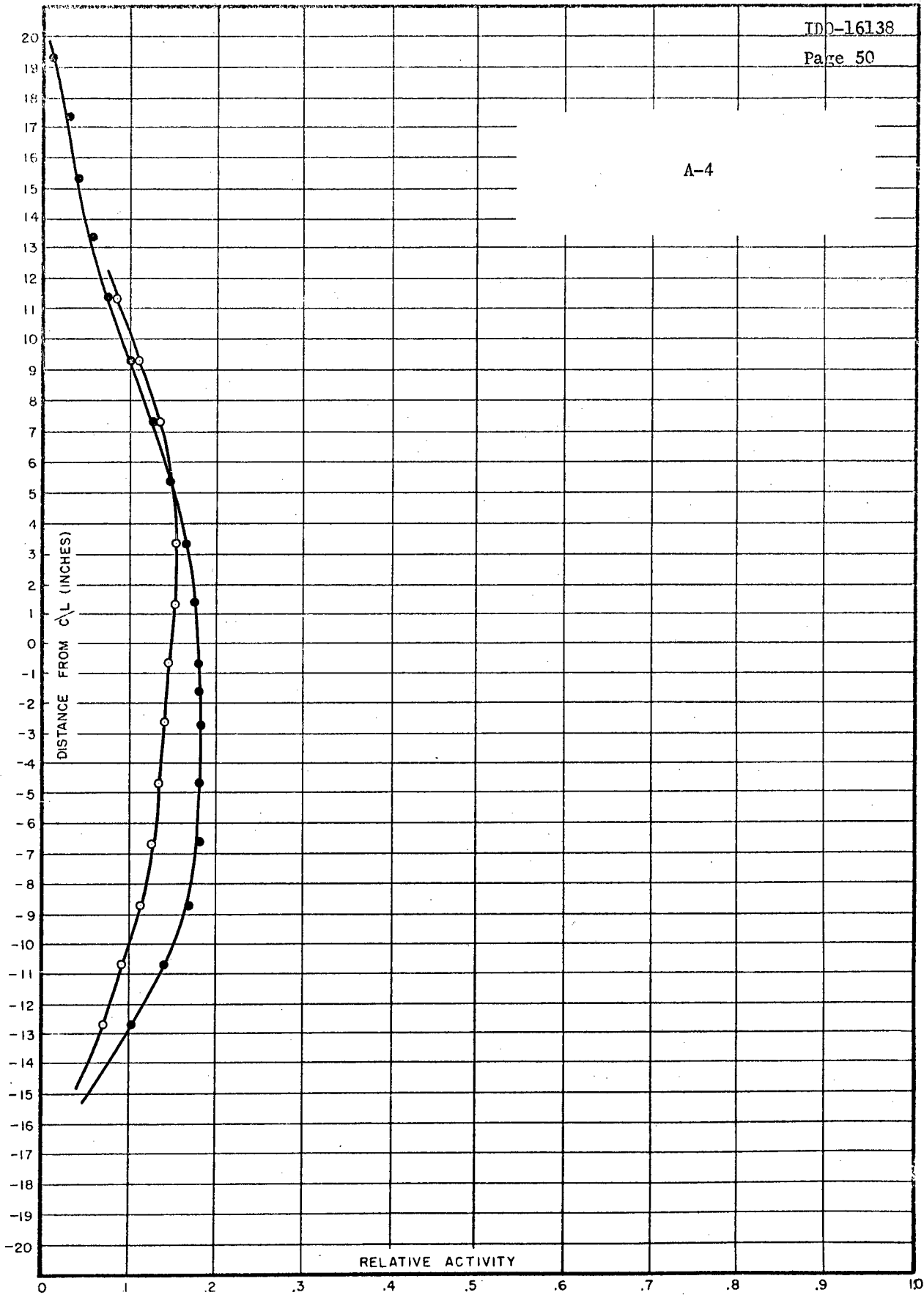


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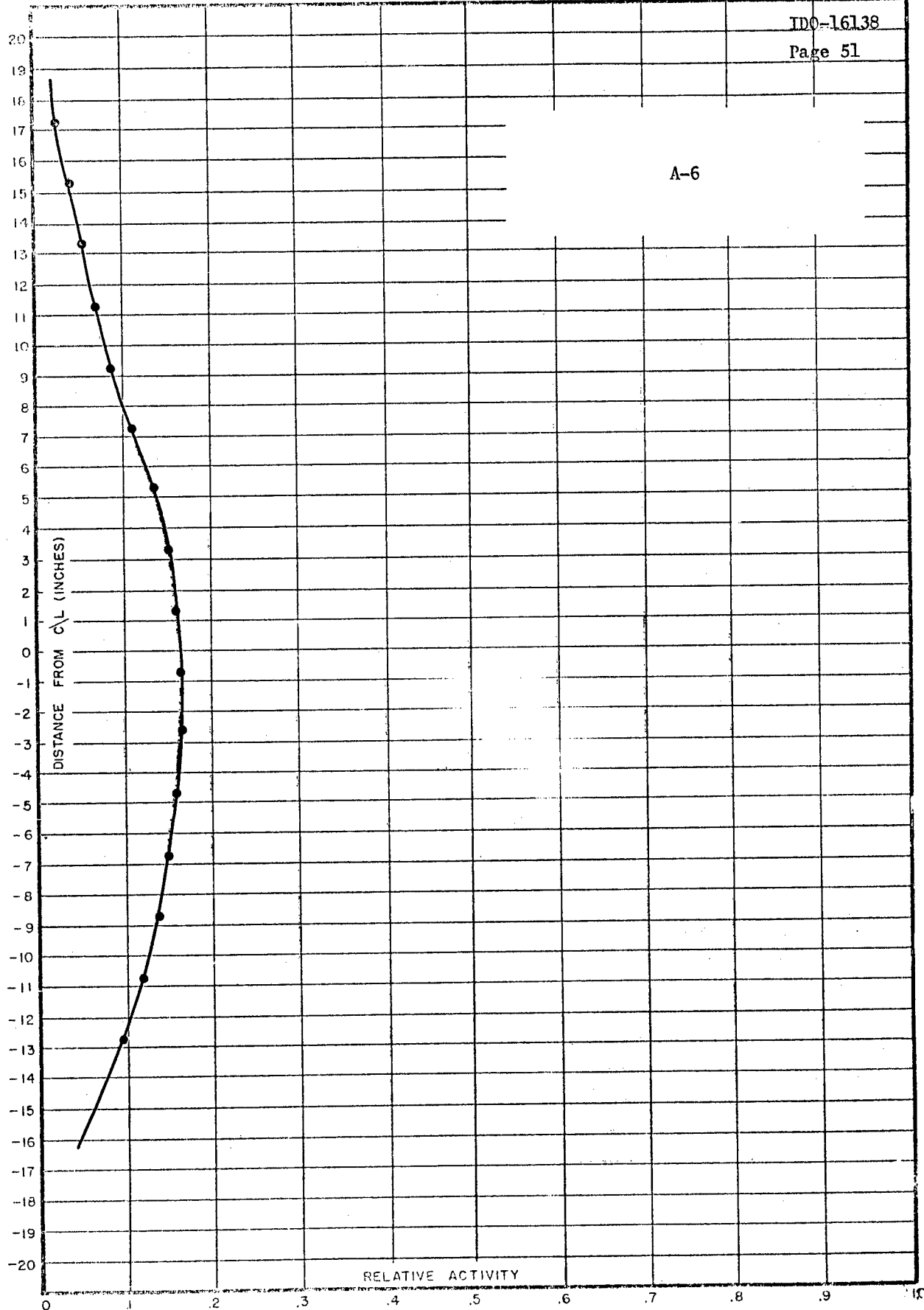


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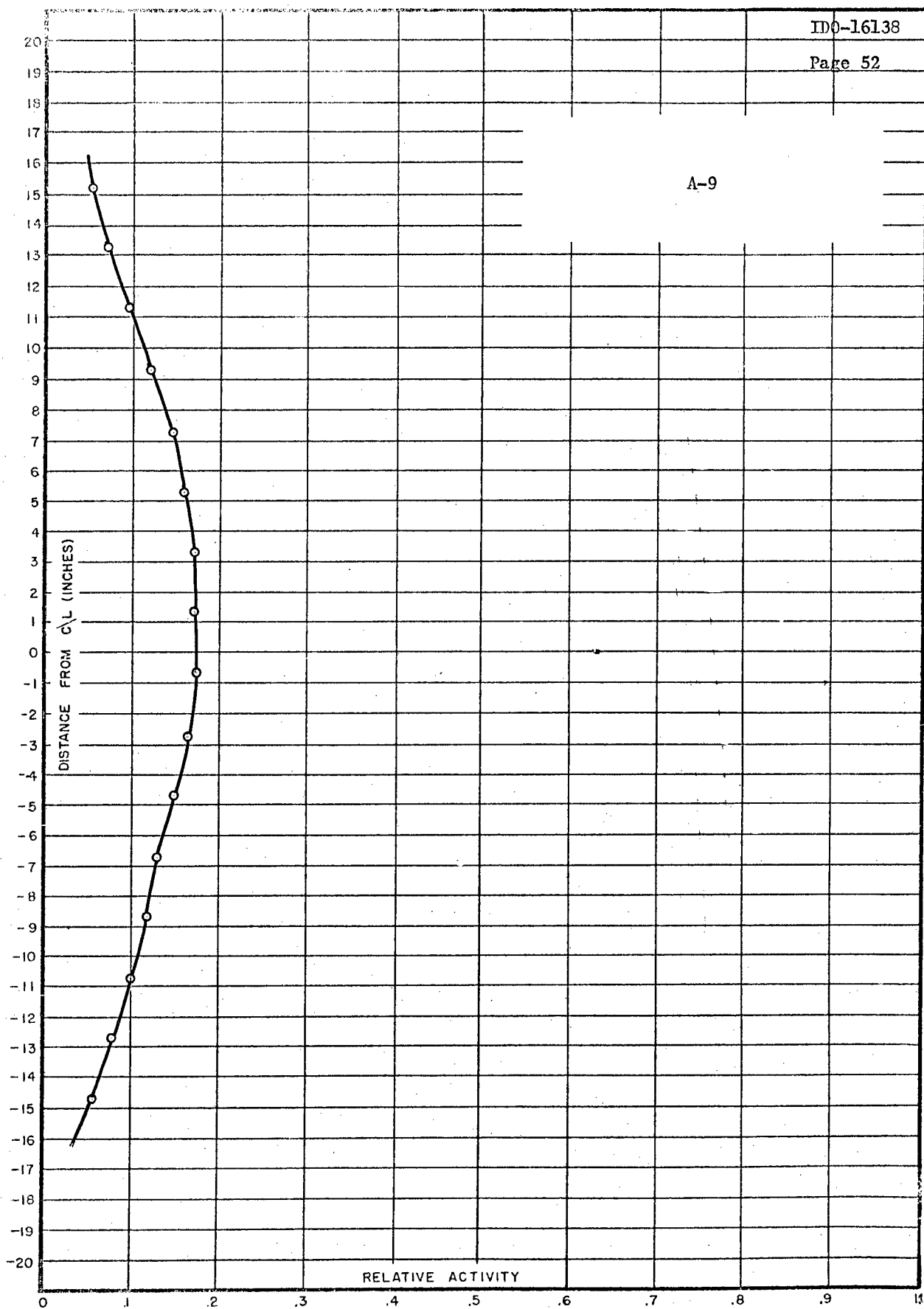




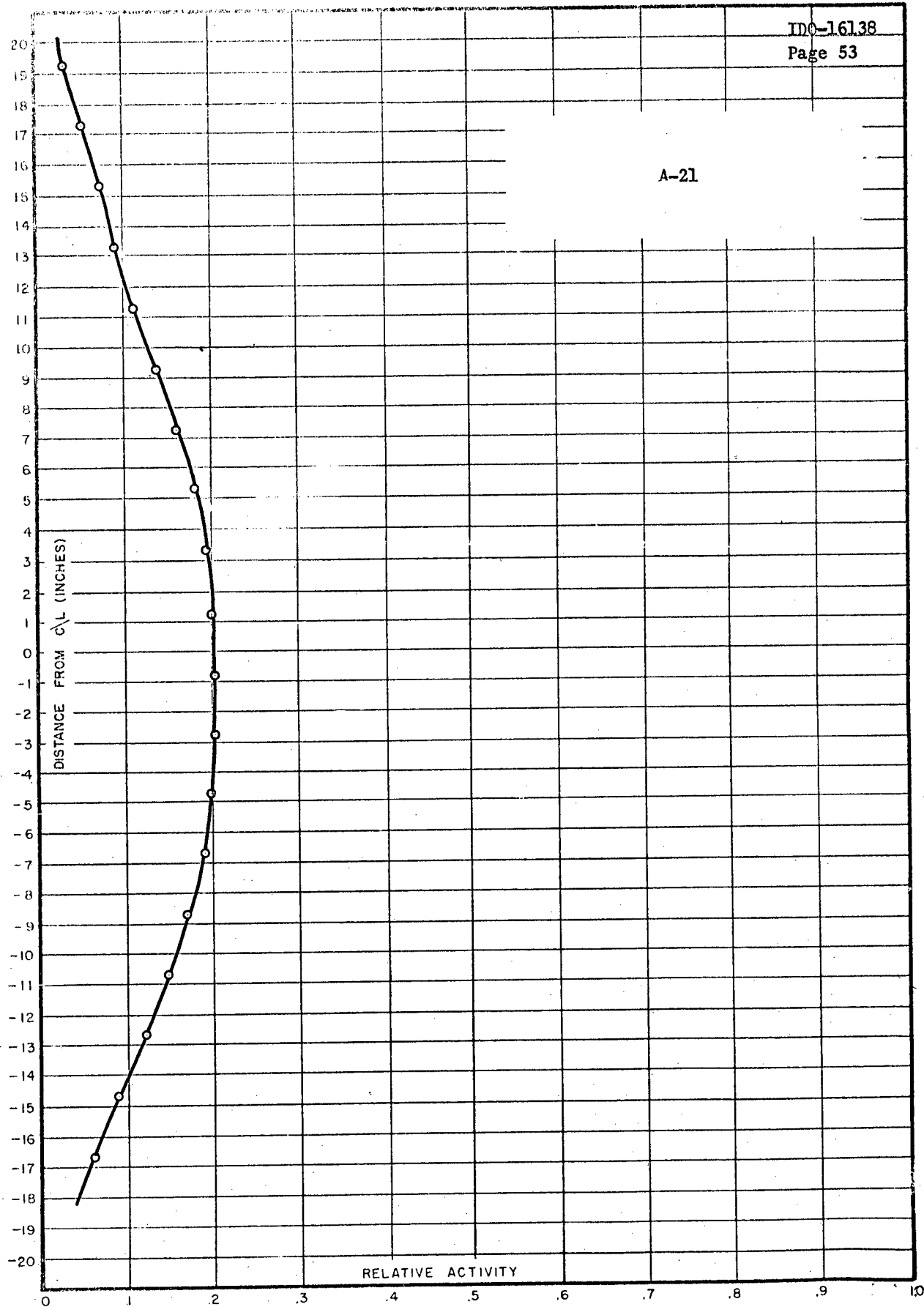
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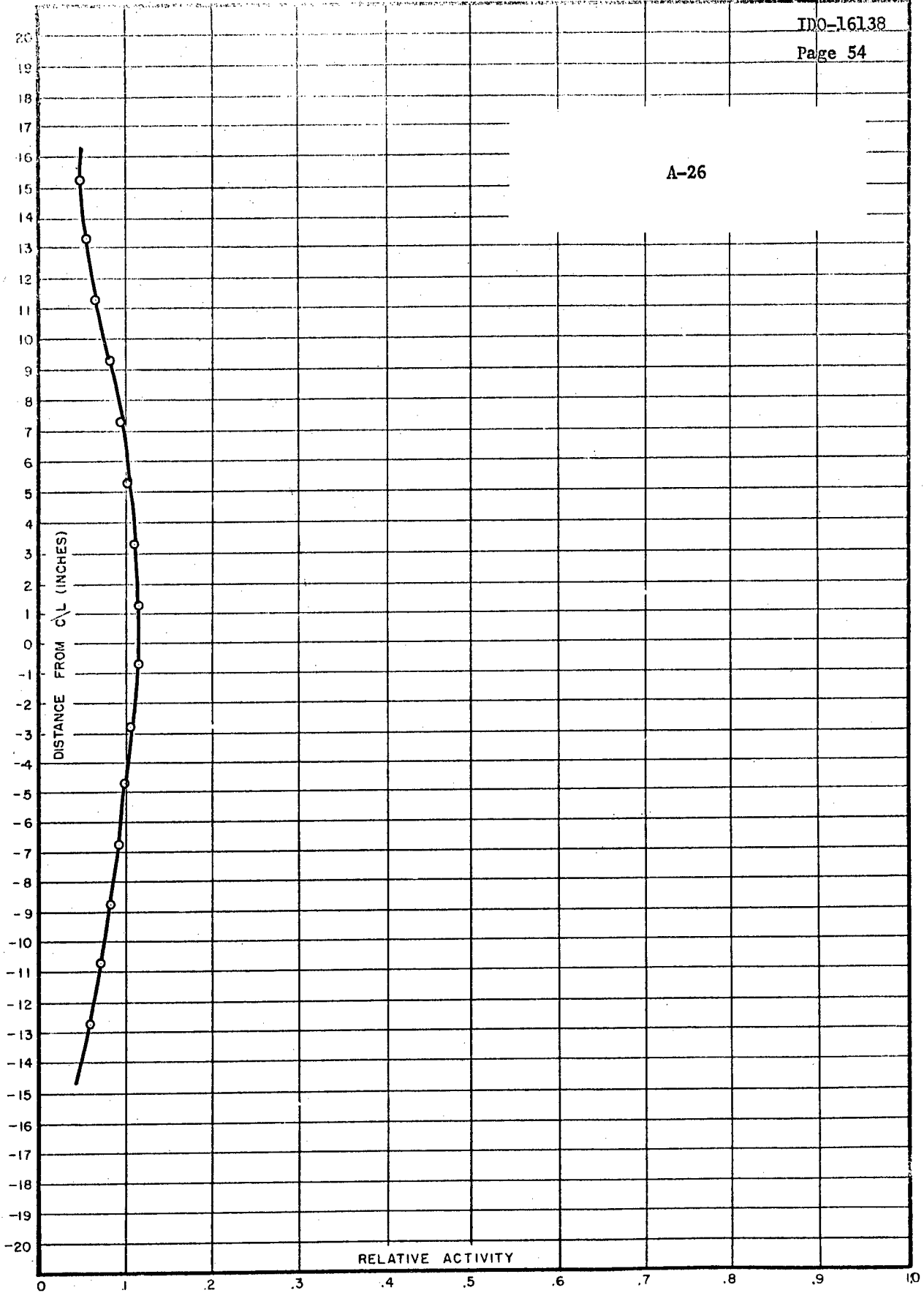
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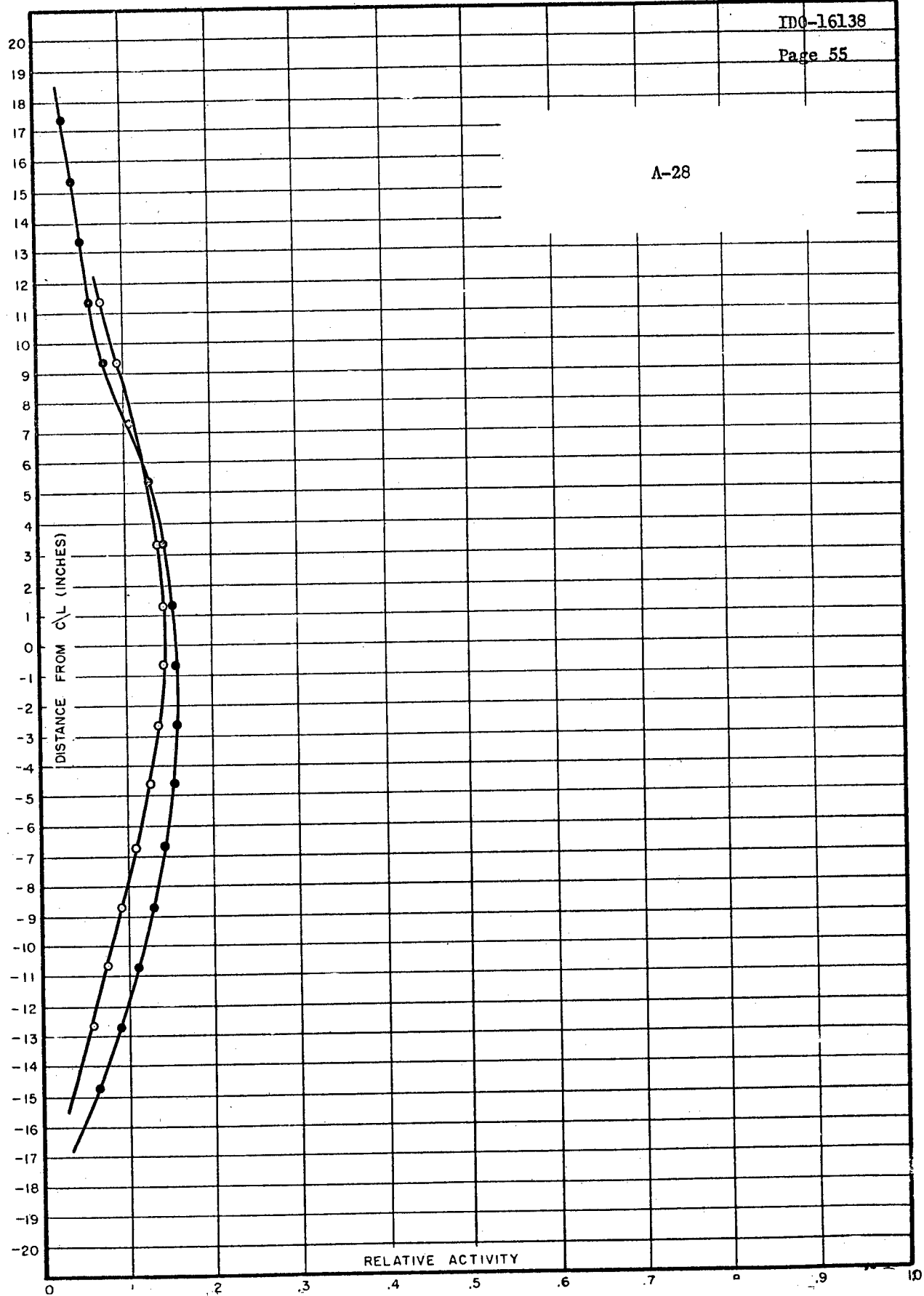
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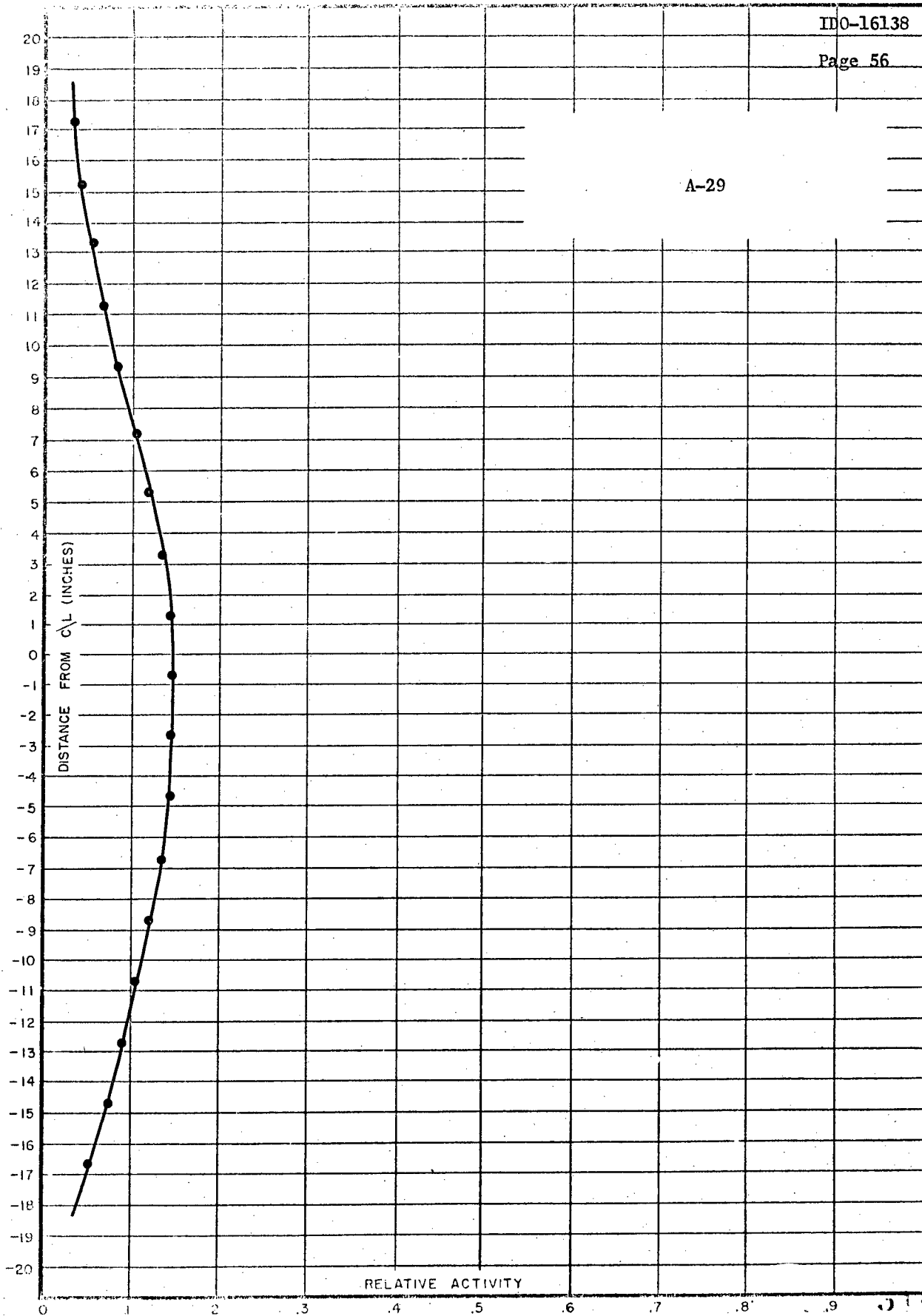
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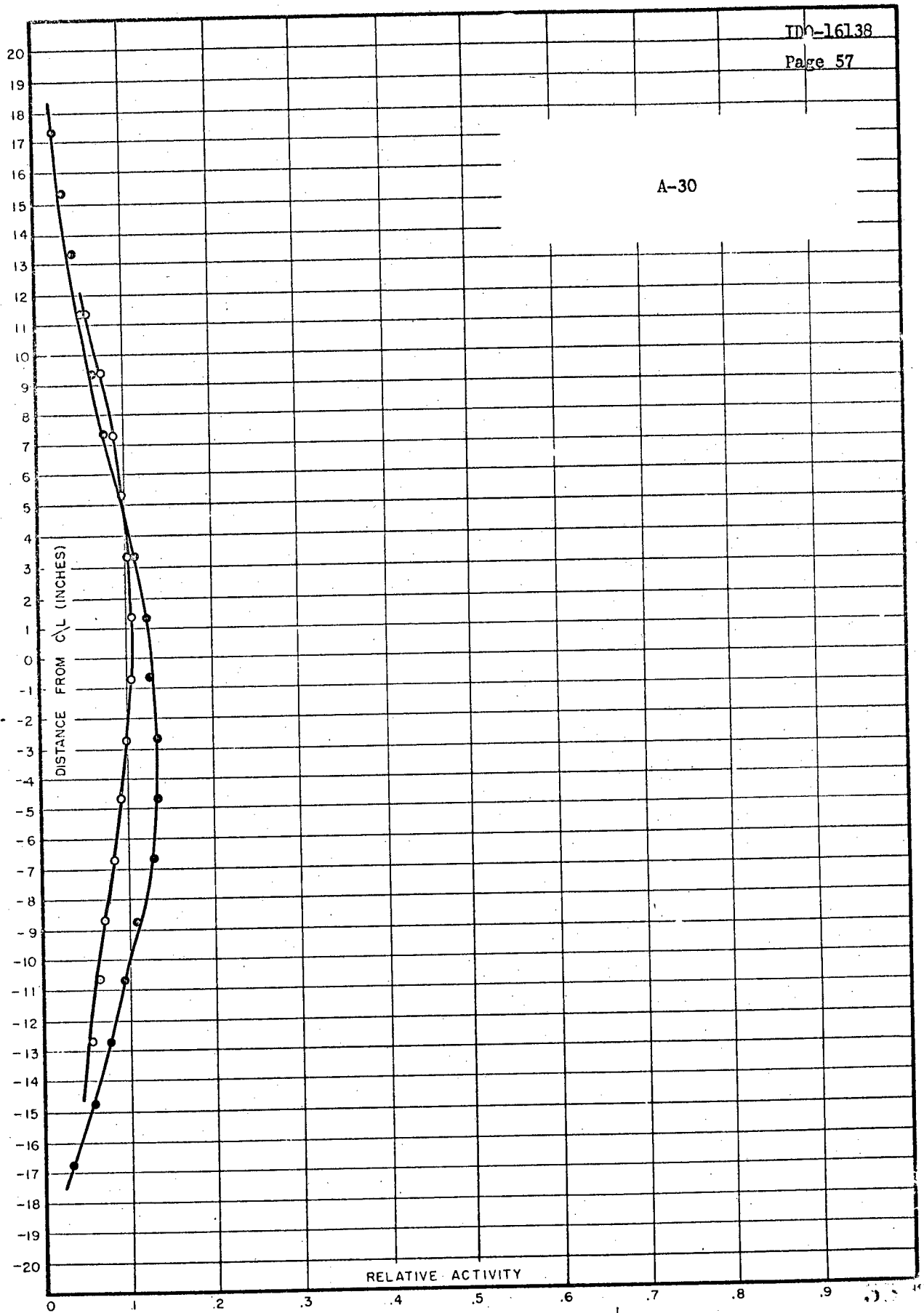


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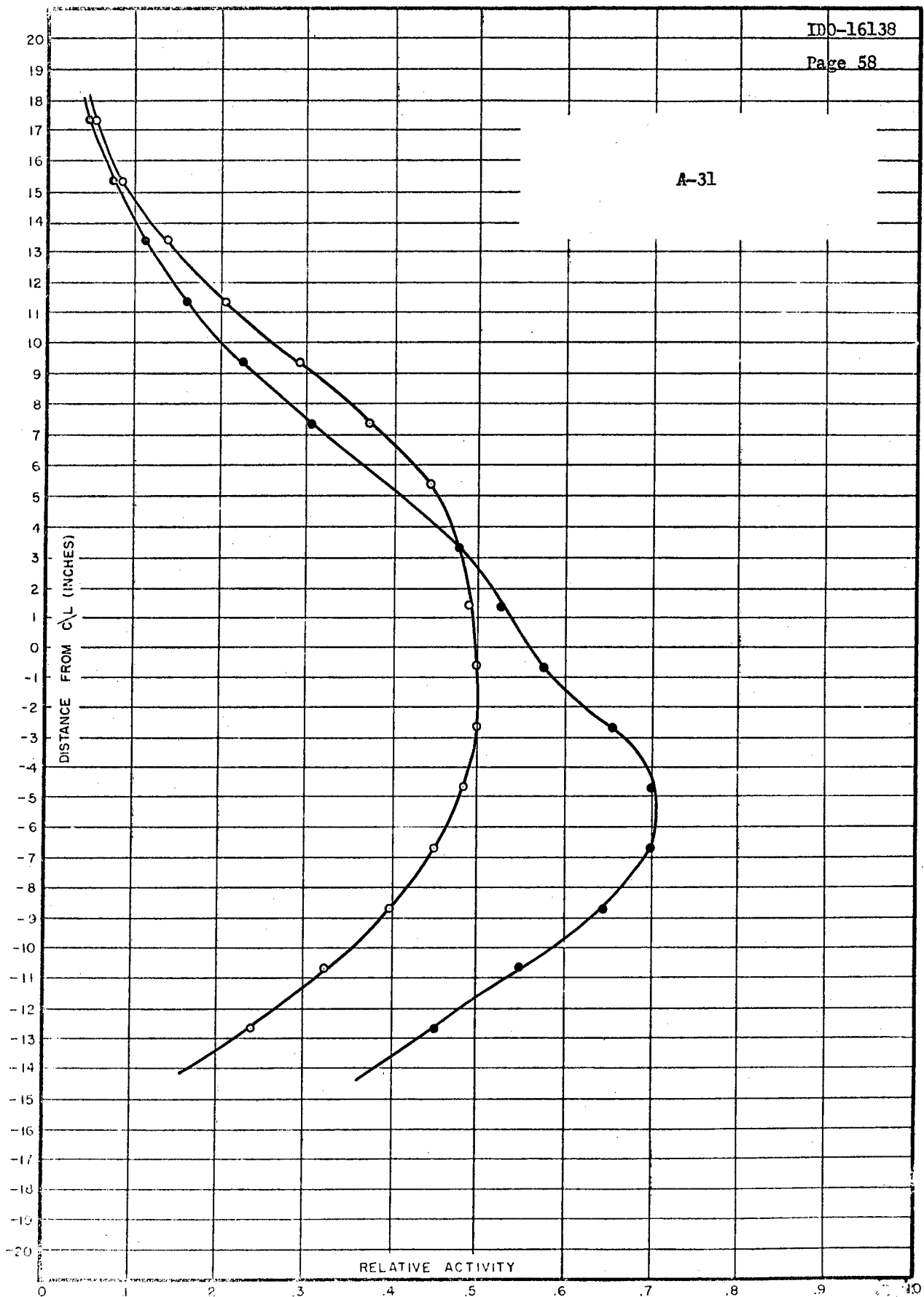


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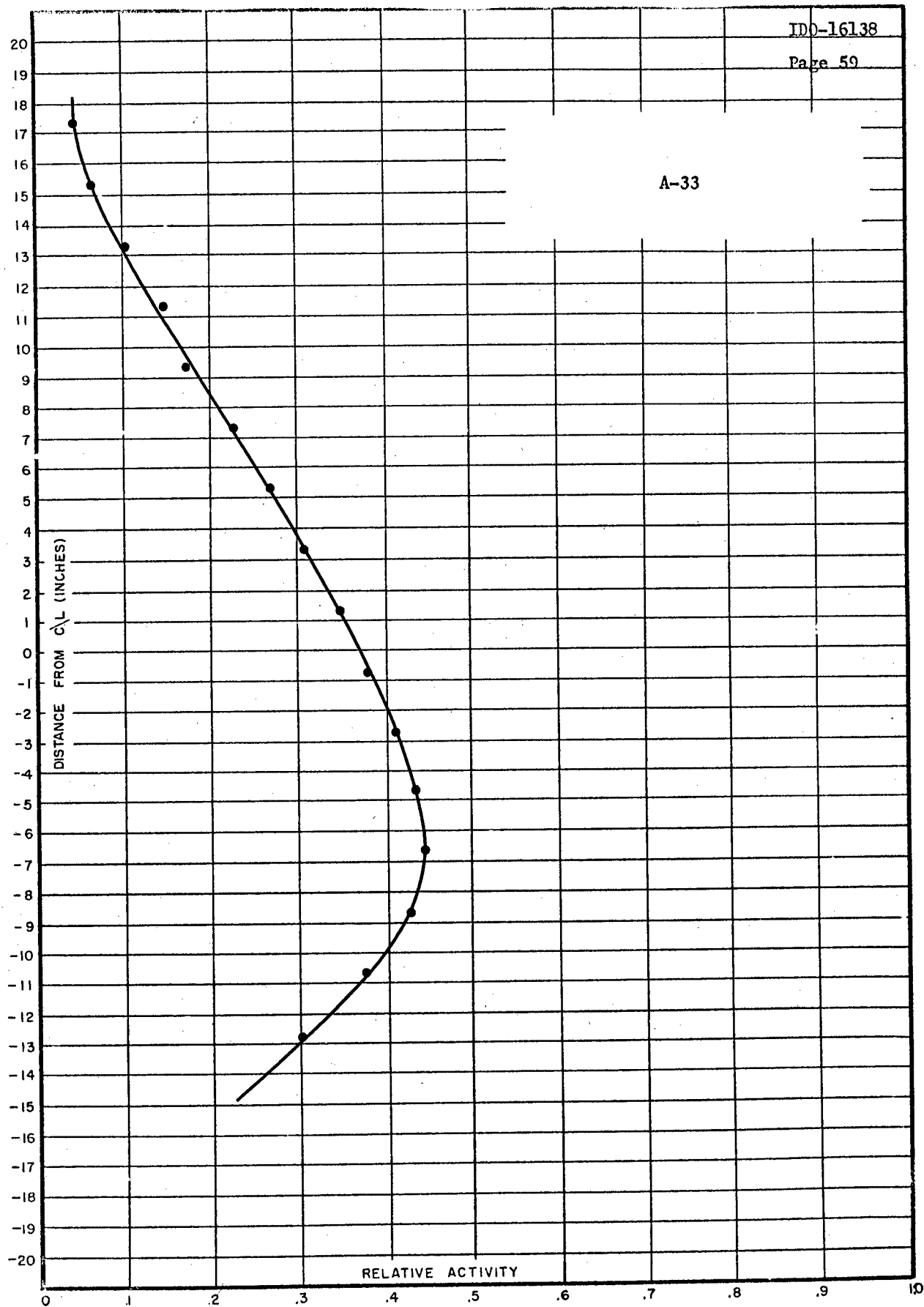


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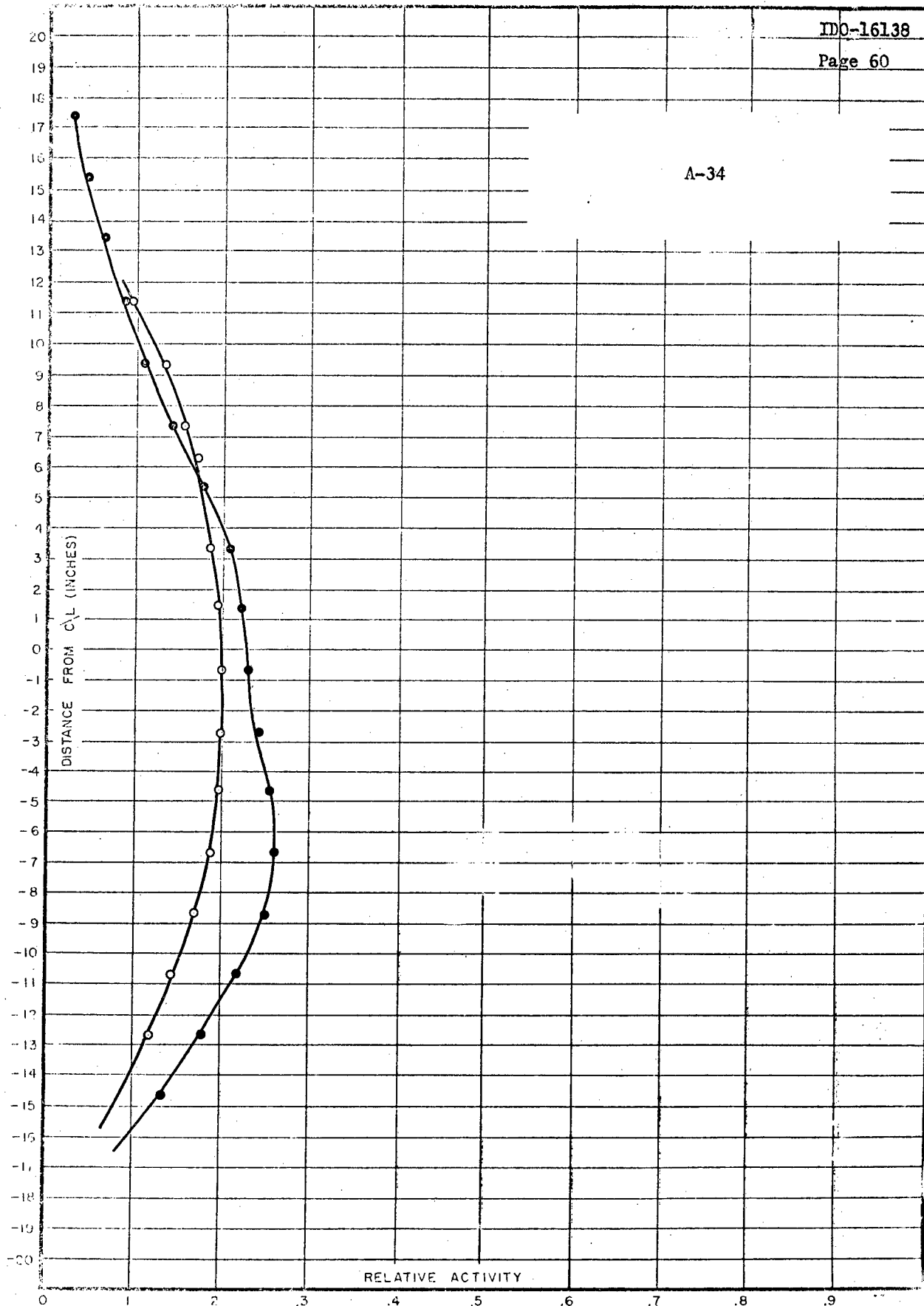


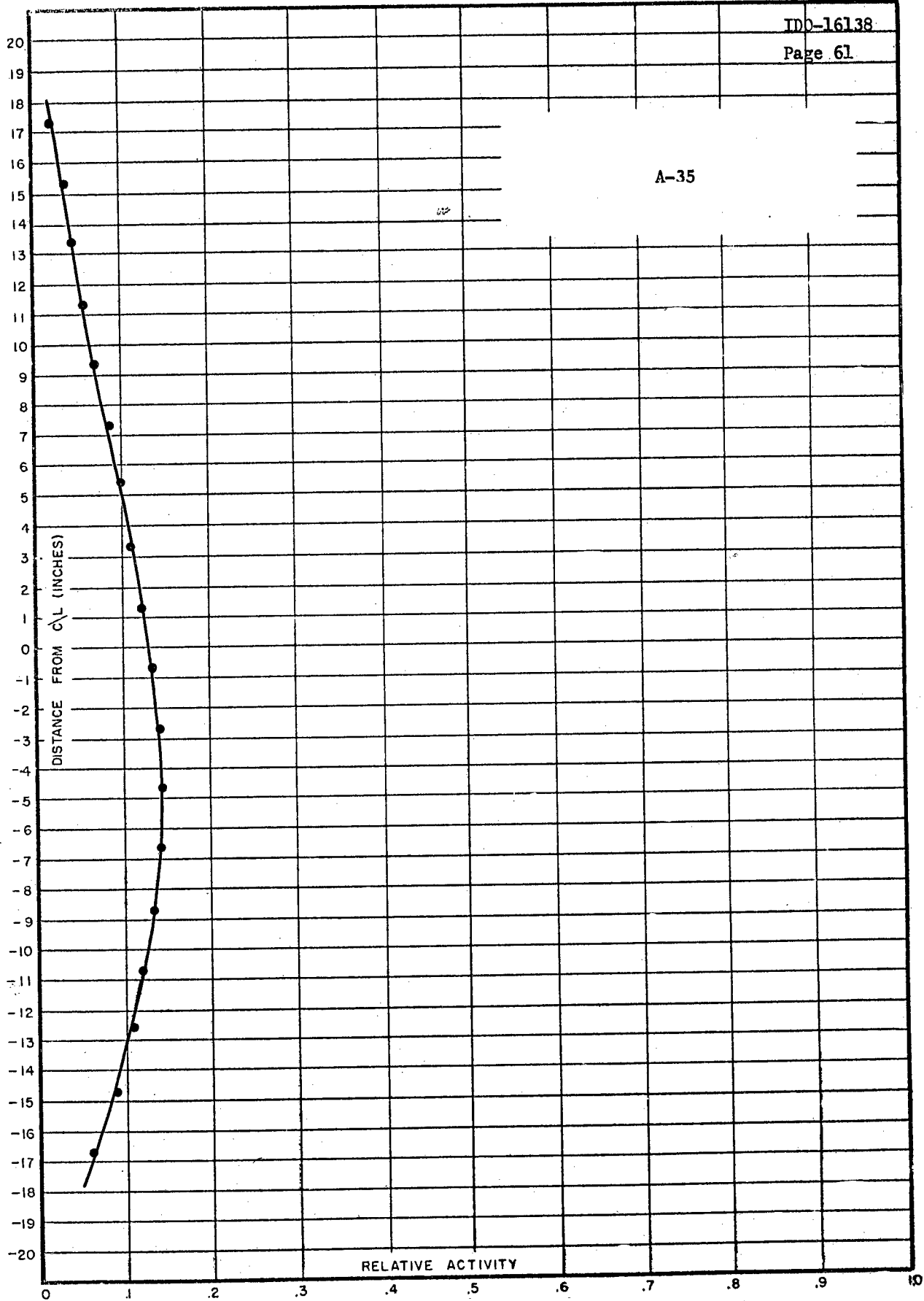


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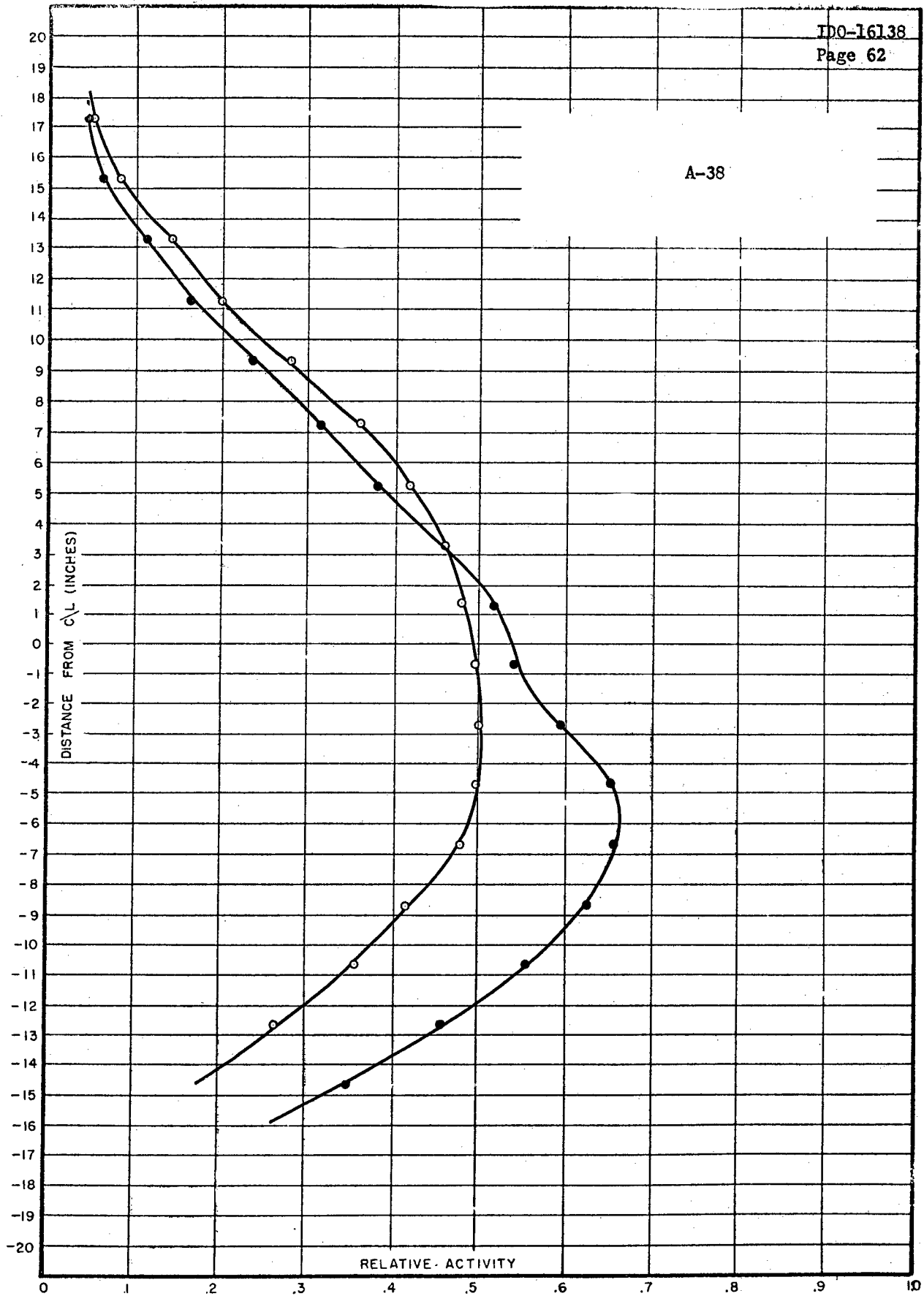


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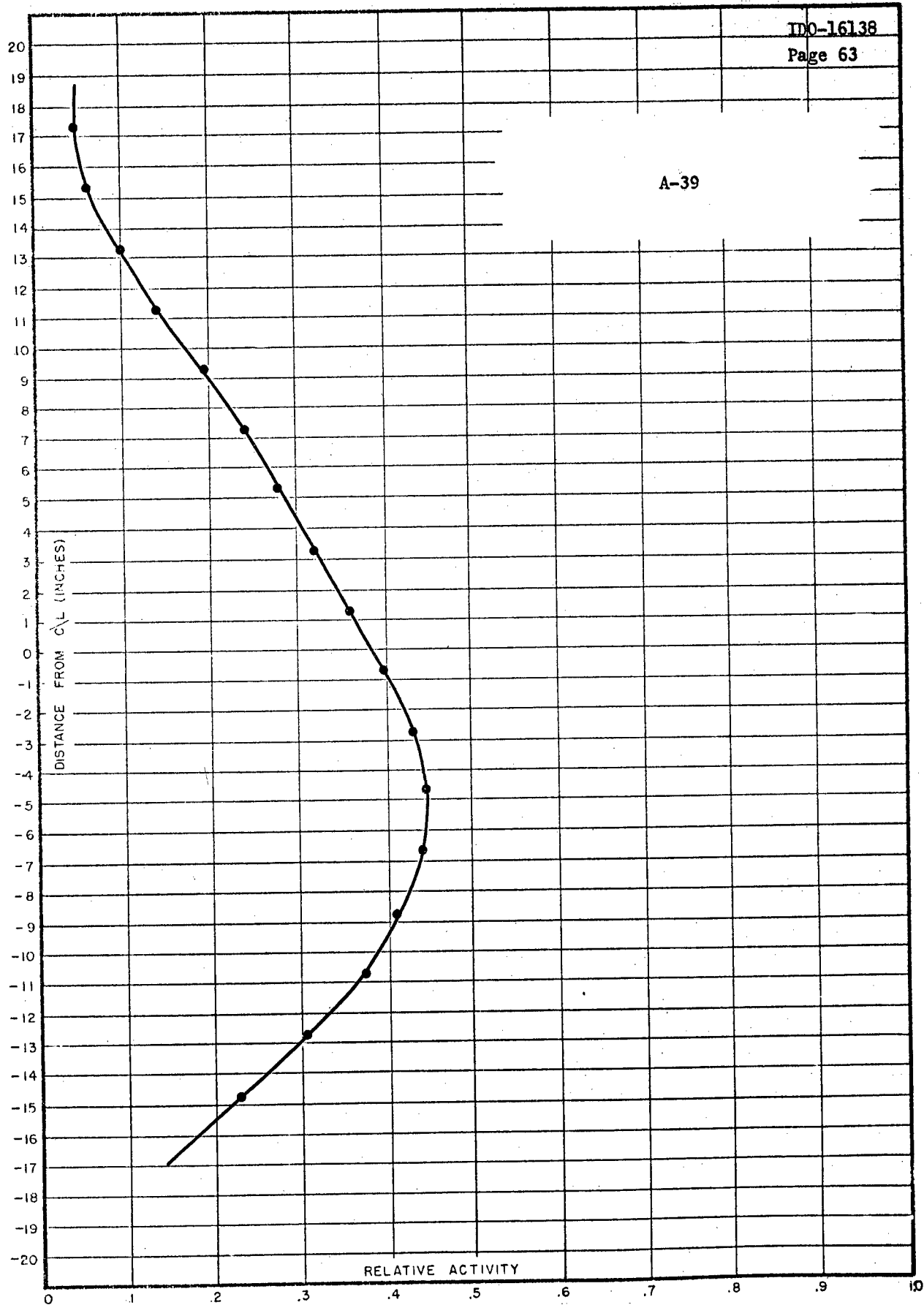




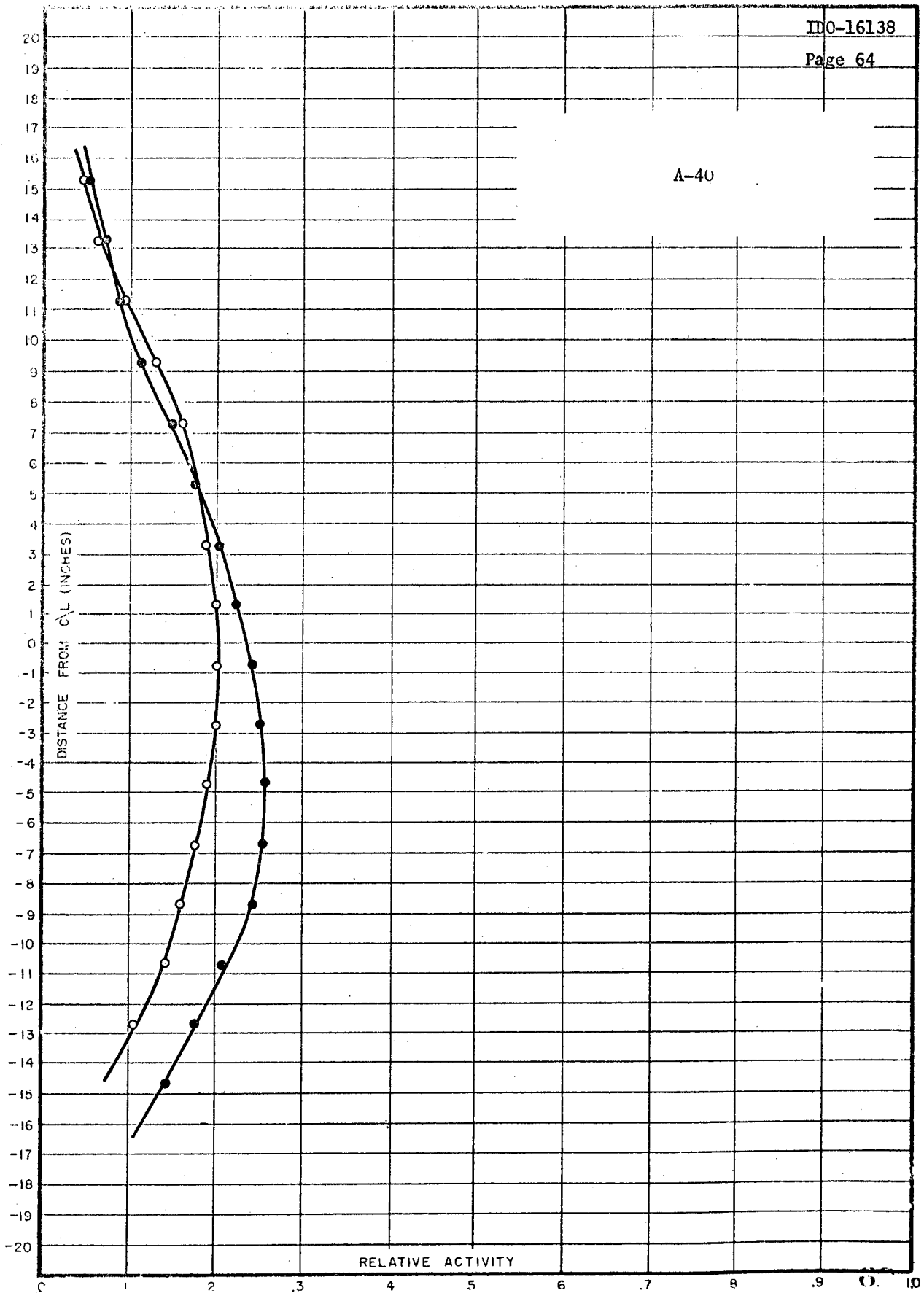
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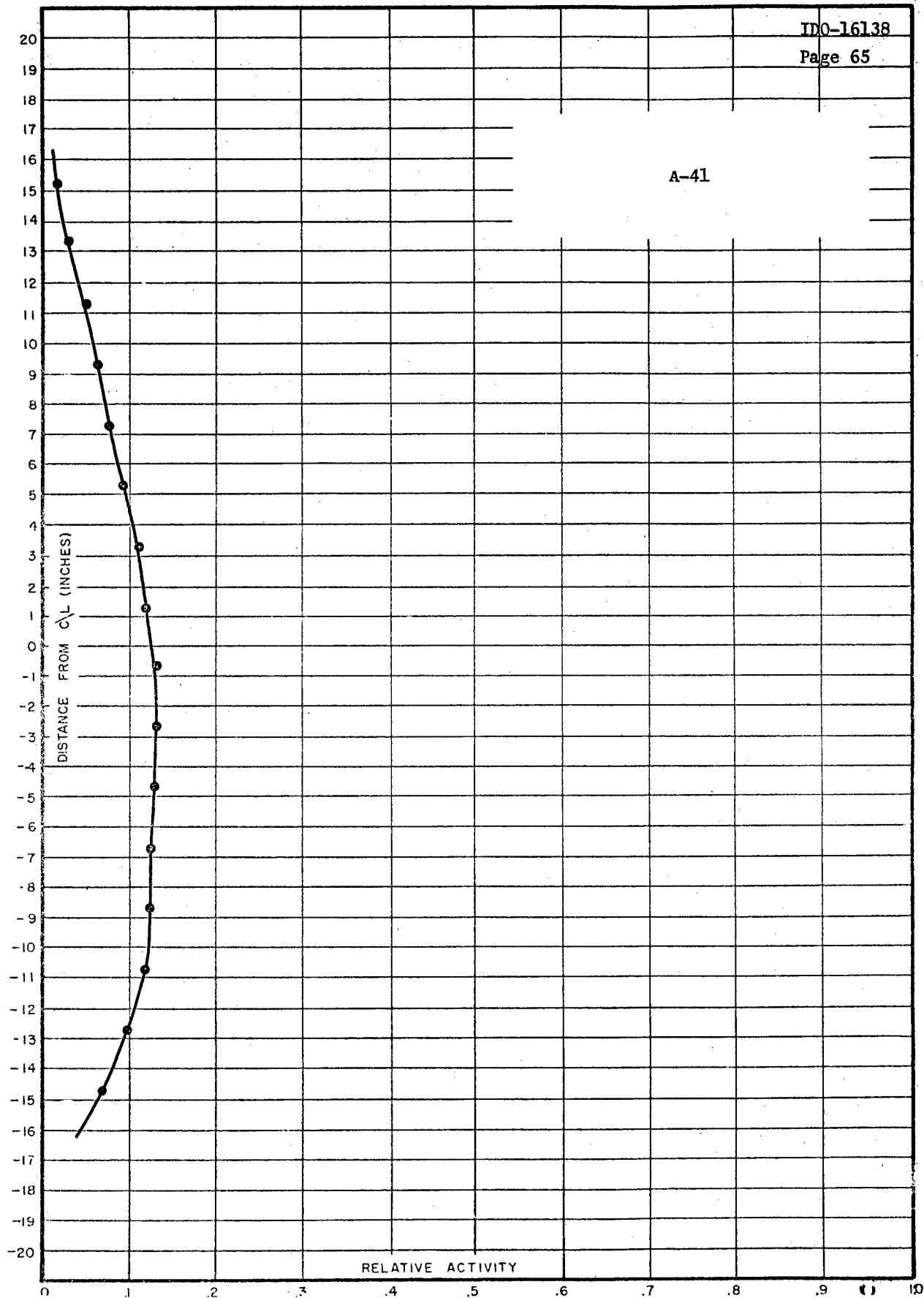


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A-40





A-43

